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THE DEMAND AND PRICE STRUCTURE FOR BYPRODUCT FEEDS
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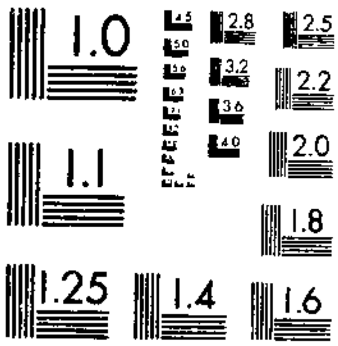

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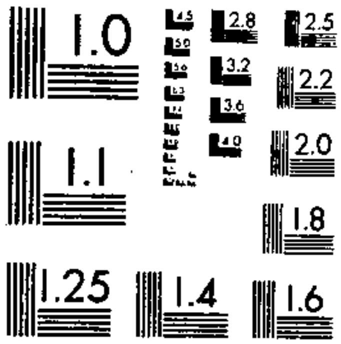

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August, 1958

The Demand and Price Structure for BYPRODUCT FEEDS

by Gordon A. King
Agricultural Economic Statistician
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PREFACE

This bulletin describes the principal economic variables that affect the demand for high-protein and other byproduct feeds. It is the fourth study in a series designed to describe the economic relationships that exist within the feed-livestock economy and the supply-demand forces that affect the different concentrates. Although the production of individual byproduct feeds is small relative to production of the principal feed grain—corn—, in the aggregate these feeds comprise an important part of feed concentrate supplies, especially as a source of protein. Demand interrelationships among the individual protein feeds, and between the high-protein feeds and the feed grains, are analyzed, and statistical price-estimating equations are presented for the aggregate of all high-protein feeds and for the principal individual byproduct feeds. In addition, this bulletin brings together data relating to production and utilization of these feeds. It is intended primarily for technical research workers in agricultural economics but should also aid extension workers, Government officials, and members of the trade in understanding the complex forces that affect the prices of these byproduct feeds, and the extent to which these forces act differently upon the individual feeds. Its benefit to farmers are expected to come through extension and other government personnel who work directly with farmers.

This study should be used in conjunction with the other three research reports on the feed-livestock economy. The first discusses the major economic forces within the entire feed-livestock economy, particularly as they relate to consumption and price of feed concentrates. It includes also a discussion of special factors that affect the price of corn, together with statistical studies of price, consumption, and sales of corn. This investigation is published in Technical Bulletin 1061, "The Demand and Price Structure for Corn and Total Feed Concentrates," by Richard J. Foote, John W. Klein, and Malcolm Clough. The second report is Technical Bulletin 1070, "Statistical Analyses Relating to the Feed-Livestock Economy," by Richard J. Foote, and presents in detail the statistical and analytical aspects of a number of studies referred to in the first bulletin. It includes a 4-equation model of the principal relationships in the feed-livestock economy which relates primarily to the November–May period; however, an iterative approach is developed which allows estimation of prices for the July–September period. The third report, dealing with the secondary feed grains, is Technical Bulletin 1080, "The Demand and Price Structure for Oats, Barley, and Sorghum Grains," by Kenneth W. Meinken. This bulletin appraises the demand for these grains in relation to that for corn and total feed concentrates.

To avoid duplication, the feed-livestock economy as a whole is only briefly discussed here.

Results from a number of statistical analyses are summarized in this bulletin. Those for the aggregate of total high-protein feeds relate to a longer time period, but this aggregate has changed considerably over time. Soybean meal, currently the most important by-product feed, increased in importance rapidly. The number of years of data available for statistical analyses of this feed is limited at this time. Thus, although appropriate methods of analysis and tentative results are given based on currently available series, further work on this important feed will be required in future.

Information was obtained from specialists throughout the United States Department of Agriculture. Special acknowledgment is made to Richard J. Foote and Malcolm Clough for valuable suggestions and assistance throughout the study. Many of the calculations were made under the supervision of Viola E. Culbertson and Martha N. Condee. Extensive use was made of both published and unpublished material in the files of the Agricultural Marketing Service.

The study on which this report is based was made under authority of the Agricultural Marketing Act of 1946 (RMA, Title II).

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THE DEMAND AND PRICE STRUCTURE FOR BYPRODUCT FEEDS

by

Gordon A. King, Agricultural Economic Statistician, Agricultural Marketing Service

HIGHLIGHTS

The major contributions of this bulletin relate to the quantification of demand interrelationships between high-protein feeds and feed grains, and to demand relationships among the various individual byproduct feeds. The statistical analyses were fitted, in general, to the periods 1921–41 and to 1921–41 plus 1946–54. These analyses suggest that the demand for high-protein feeds for the period between World Wars I and II was less elastic than in the postwar years, although the coefficients do not differ from each other by a statistically significant amount. The indicated elasticity of demand for high-protein feeds in the interwar period is about unity, compared with −1.6 for an analysis that includes both the pre- and post-World War II years. An increase in the elasticity of demand for feed grains also is suggested. This and other studies suggest that the direct elasticity for high-protein feeds is approximately twice as elastic as that for feed grains. High-protein feeds and feed grains appear to have been strongly competitive on the average in these years.

Determination of demand coefficients for individual high-protein and other byproduct feeds is difficult, owing to the interrelationships with other feeds. For some items, regional conditions of supply and demand are important. The two most important high protein feeds, in terms of volume used, are soybean and cottonseed meals. Statistical analyses suggest a certain independence in demand for these items, and also for linseed meal, reflecting differences in their physical characteristics and their relative value in rations for various types of livestock. Studies for the individual feeds confirm the expectation that demand for an individual feed is more elastic than for the aggregate of total feeds, although the indicated specific level of elasticity differs depending on the exact way in which the analysis is formulated and the years used. Statistical analyses are shown for each of the more important byproduct feeds, and a discussion of factors that affect relative prices is given for other items. Statistical series on supply and disposition that relate to each feed also are shown.

Since byproduct feeds are used extensively in commercially prepared feeds, attention is given to the formulation of various poultry and livestock rations and to trends in the prepared feeds industry. In terms of tonnage of manufactured feeds, poultry feeds are by far the most important. A detailed description is given of the economic and nutritive factors that determine the composition of various poultry rations. A decision as to the type of feed to be used to produce broilers, for example, depends on the prices of the various ingredients, total feed requirements of the birds, the rates of substitution between the various feeds, and the time required for growth. Nutritional advances, over time, such as the isolation of vitamin B-12 and its subsequent synthetic production, have influenced the relative importance of feed ingredients in poultry and livestock rations. The effects of several such developments are discussed in detail. The importance of a knowledge of the production functions for the various poultry and livestock products is illustrated for hogs, since the demand for feed inputs is basically associated with these relationships and the demand for livestock products.

Prices of oilseed meals tend to drop markedly at the start of the new crushing season, reflecting a seasonal increase in their supply. There is less seasonal variation in the price of soybean meal than for certain byproduct feeds—such as dehydrated alfalfa meal and fish meal—with a more marked seasonal pattern of production. The seasonal variation in prices of soybean meal is greater than that for items like meat scraps that have little seasonal variation in production. The variation in prices appears to be associated in part with available supplies of the meal, though other factors, such as seasonal requirements for protein supplements, exert important influences on the pattern of prices by months. Also, some variation in crushings occurs during the season, depending on the price of oilseeds and oil and meal.

TRENDS IN UTILIZATION

In general, byproduct feeds is a collective term applied to products of other industries that are used for livestock feed. They are important, especially, as a source of protein for livestock rations. For purposes of analysis the several feeds are classified according to their relative protein content, although for some, other nutritive factors are fully as important. Domestic production provides nearly all of the quantities fed in recent years, with the notable exceptions of fish and copra meals and molasses. Utilization for purposes other than feed is not important at present, as only about 2 percent of oilseed meal supplies was exported in the 1950-54 period and about 1 percent used for food and industrial purposes.

Byproduct feeds accounted for an average of 18 percent of the total tonnage of concentrates fed to livestock and poultry during the 1950-54 October-September feeding years. High-protein feeds—those with a protein content of 20 percent or more—averaged 13 million tons or about 10 percent of total concentrates fed. These high-protein feeds, however, supplied roughly 35 percent of the total digestible protein, whereas other byproduct feeds supplied about 8 percent, and grains the remaining 57 percent. Total concentrates are the source of about 40 percent of the protein fed to livestock, with roughages contributing 60 percent (*26*, p. 5).[1]

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[1] Italic numbers in parentheses refer to Literature Cited, p. 134.

HIGH-PROTEIN FEEDS

This classification includes three subgroups: (1) The oilseed meals—soybean, cottonseed, linseed, peanut and copra meals; (2) animal and marine proteins, which include meat scraps, tankage, commercial and noncommercial milk products, and fish byproducts; and (3) certain grain byproducts, including gluten feed and meal, brewers' dried grains, distillers' dried grains, and dried solubles. The upward trend in total supplies of high-protein feeds is illustrated in figure 1. Quantities of these feeds are expressed in soybean meal equivalent, converted on the basis of digestible protein content.[2] An animal unit series is shown that reflects changes in animal numbers based on the importance of high-protein feeds in the various livestock rations. Supply per animal unit also is given in figure 1. Quantities available for feeding increased from an average of 111 pounds per high-protein feed consuming animal units in 1926–30 to 228 pounds in 1950–54. The quantity of the four feed grains fed per grain-consuming animal unit increased by 10 percent in the same period. Changes in quantities fed of the various classes of byproduct feeds and feed grains are summarized in table 1 for selected periods.

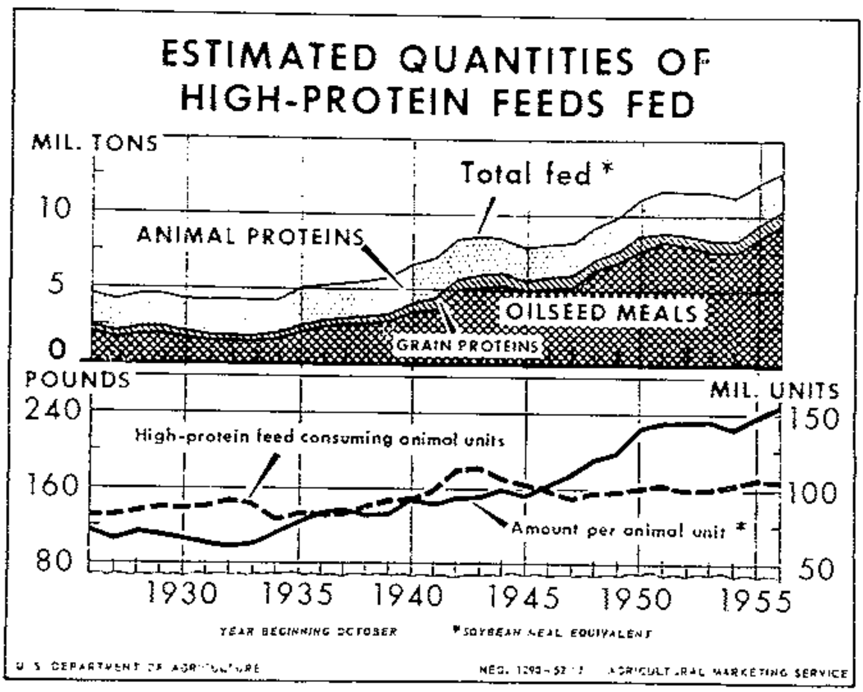

Figure 1. The marked upward trend in the quantity of high-protein feeds fed, both in total and per animal unit over the past 2 decades, indicates an improvement in the protein adequacy of livestock rations. However, the quantity of protein feed required per animal also has increased to match the heavier feeding of lower protein feeds and to offset the decline in protein content of corn.

[2] See Appendix pp. 138–54 for actual series and methods used in conversion.

TABLE 1.—*Byproduct feeds and feed and food grains: Quantity fed, averages 1926–30, 1939–41 and 1950–54*

Amount fed	Year beginning October			Percentage change in quantity fed in 1950–54 from[1]—	
	1926–30	1939–41	1950–54	1926–30	1939–41
Byproduct feeds:	*Million tons*	*Million tons*	*Million tons*	*Percent*	*Percent*
High-protein:					
Oilseed meals [2]	2.5	4.2	8.8	249	108
Animal [3]	2.8	3.0	2.8	2	−6
Grain [4]	.7	1.2	1.6	114	31
Total	6.0	8.4	13.2	119	56
Medium-protein:					
Wheat millfeeds	5.0	4.7	4.7	−5	2
Alfalfa meal	.4	.5	1.2	273	139
Total	5.4	5.2	5.9	12	16
Other:					
Dried and molasses beet pulp	.2	.3	.5	122	53
Rice millfeeds	.1	.1	.2	170	107
Miscellaneous [5]	2.0	2.0	3.2	59	59
Total	2.3	2.4	3.9	69	61
Total byproduct feeds	13.7	16.0	23.0	69	44
Grains:					
Feed grains	87.3	89.4	101.7	16	14
Wheat and rye	2.8	4.3	2.8	−1	−34
Total grains	90.1	93.7	104.5	16	12
Grand total	103.8	109.7	127.5	23	16

[1] Percentage changes calculated from unrounded data.
[2] Includes soybean, cottonseed, linseed, peanut, and copra meals.
[3] Includes tankage, meat scraps, fish byproducts, commercial and noncommercial milk products. The 1954 quantity of tankage and meat scraps included in this average is taken at 1,073,000; the unrevised figure, comparable with prior years. Revised data for 1954 and subsequent years are given in tables 8 and 74.
[4] Includes gluten feed and meal, corn oilmeal, and brewers' and distillers' dried grains.
[5] Includes estimated quantities of hominy feed, oat millfeeds, molasses, and screenings fed to livestock.

Soybean Meal

Feed uses.—In 1950–54, soybean meal [3] accounted for 62 percent of the total tonnage of oilseed meals fed, 41 percent of all high-protein

[3] The term "meal," as used in this bulletin, includes quantities produced and sold as meal or flakes from the solvent extraction process; meal or cake from the hydraulic process; meal or chips from the screw-press process; meal from grinding undefatted beans; and quantities sold in cube or pellet form.

feeds fed, and 24 percent of all byproduct feeds fed. It has been the most important protein supplement since about 1942. In 1926–30, 84,000 tons were fed annually, of which more than half was imported, but by 1939–41 the quantity fed annually increased to 1,517,000 tons, and by 1950–54, to 5,452,000 tons. Soybean meal is used extensively in formula feeds; Jennings (*27*, p. 19) estimates that 86 percent of the total quantity fed was so utilized in the year beginning October 1949. For this year, poultry on farms consumed 42 percent of the total quantity fed; hogs, 29 percent; dairy cattle, 20 percent; and all other livestock, 9 percent.

Although soybeans are processed by three methods—mechanical pressing, solvent extraction, and grinding undefatted soybeans—the solvent extraction method currently accounts for about 95 percent of the total. Soybean oil and meal are the principal products, but some processing is done to obtain flour instead of meal. Full-fat flour is obtained by grinding undefatted soybeans, and low- or medium-fat flour, by the solvent extraction and mechanical processing methods, respectively. Also lecithin is produced mainly for use in food. Soybean flour is used both for edible and industrial purposes. The relative importance of the several nonoil byproducts of soybean processing, as reported by the Census (*59*, p. 18) for 1954 is as follows:

Soybean nonoil products:	*Thousand tons*
Cake and meal	5, 061
Industrial soy flour	38
Lecithin	13
Edible soy flour, full-fat	5
Other	63

Trends in the utilization of soybean meal are given in table 2. Currently, nearly all meal is used as livestock feed, though exports have been important since 1946. Industrial uses in addition to industrial flour, which is reported separately, are estimated at 30,000 tons since 1950. Data shown in table 2 include small quantities of low- and medium-fat flour for years before 1949.

Industrial uses.—The more important industrial uses of soybean proteins are as woodworking glues in the manufacture of plywood and as paper coatings. Industrial uses of soy flour, meal, and protein isolate are discussed fully in a recent report on the marketing potential for all oilseed protein material (*2*). The soy-protein isolate is produced mainly by the solvent extraction method and is obtained by treating the soybean protein flakes chemically so as to remove cellulose, sugar, and other nonprotein ingredients. It is used mainly in water emulsion paints and wallpaper coatings. For 1951, an estimated 13,000 tons of soy-protein isolate were used for industrial purposes, in addition to 23,000 tons of soybean meal. Production of industrial soy flour has increased in recent years; in 1954 it amounted to 38,000 tons.

Exports.—Exports shown in table 2 for 1946–50 were largely military relief shipments of high-quality meal and low-fat flour. Exports of meal for 1951–53 averaged less than 1 percent of total supplies, but in 1954–56 about 6 percent of supplies were exported. In most years, exports have not been important.

Imports.—Imports of meal were larger than domestic production until 1930, and they accounted for a significant proportion of supplies

TABLE 2.—*Soybean meal: Supply and disposition, 1921–56*

Year beginning October	Supply				Disposition		
	Stocks, October 1[1]	Production[2]	Imports	Total	Exports[3]	Food and industrial uses[4]	Use for feed[5]
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1921		1.3	[4] 2.1	3.4			3.4
1922		3.8	12.3	16.1			16.1
1923		2.4	21.1	23.5			23.5
1924		7.6	18.3	25.9			25.9
1925		8.6	19.8	28.4			28.4
1926		8.3	23.9	32.2			32.2
1927		13.7	47.7	61.4			61.4
1928		21.5	69.5	91.0			91.0
1929		40.7	73.5	114.2			114.2
1930		98.6	24.0	122.6			122.6
1931		114.7	18.6	133.3			133.3
1932		84.3	28.3	112.6			112.6
1933		73.9	25.0	98.9			98.9
1934		220.4	64.2	284.6		18.0	266.6
1935		613.1	20.0	633.1		19.0	614.1
1936		495.8	55.7	551.5		20.0	531.5
1937		724.1	15.5	739.6		21.0	718.6
1938		1,064.4	12.3	1,076.7	[4] 35.0	22.0	1,019.7
1939		1,348.8	12.1	1,360.9	62.3	23.0	1,275.6
1940		1,543.4	8.1	1,551.5	25.4	35.0	1,491.1
1941		1,844.9	0	1,844.9	19.7	40.1	1,785.1
1942		3,200.3	0	3,200.3	20.9	105.5	3,073.9
1943		3,446.0	0	3,446.0	16.1	107.1	3,322.8
1944		3,698.6	0	3,698.6	10.0	61.4	3,627.2
1945		3,837.3	(6)	3,837.3	1.0	181.4	3,654.9
1946		4,086.4	0	4,086.4	141.7	199.3	3,745.4
1947		3,832.7	0	3,832.7	[7] 95.7	353.8	3,383.2
1948	[8] 31.6	4,330.5	3.2	4,365.3	[7] 150.6	[9] 43.9	4,157.5
1949	13.3	4,585.6	26.1	4,625.0	[7] 47.4	25.0	4,517.4
1950	35.2	5,896.7	32.8	5,964.7	[7] 181.1	30.0	5,718.1
1951	35.5	5,703.7	24.1	5,763.3	41.8	30.0	5,640.0
1952	51.5	5,551.3	41.1	5,643.9	46.8	30.0	5,510.3
1953	56.8	5,050.6	15.6	5,123.0	66.5	30.0	4,964.9
1954	61.6	5,704.8	0	5,766.4	271.7	30.0	5,427.5
1955[10]	37.2	6,545.8	0	6,583.0	400.1	30.0	6,041.6
1956[10]	111.3	7,509.3	.1	7,620.7	443.2	30.0	7,092.8

[1] Stocks at crushers' plants. Not reported prior to February 1949.
[2] Prior to January 1949, derived from census data on crushings; January 1949 to date, compiled from *Animal and Vegetable Fats and Oils (59)* and *Fats and Oils (60)*.
[3] Meal only. Prior to 1938, not separately reported.
[4] Partly estimated.
[5] Residual. Includes small quantities utilized for food and industrial purposes for years prior to 1934.
[6] Less than 50 tons.
[7] Includes military relief shipments abroad.
[8] February 1, 1949.
[9] Beginning January 1949, estimated use of meal for industrial use only. Production of flour for food and industrial uses reported separately.
[10] Preliminary.

until 1937. Since 1937 domestic production has increased rapidly; currently, this country is a net exporter of both meal and soybeans.

Stocks.—Stocks at crushers' plants have been reported monthly since 1949. Quantities vary considerably during the crushing season, but normally reach a low point on October 1 when crushings of the new crop are usually heavy. In 1950–54, stocks on October 1 averaged 13 percent of the disappearance during September, whereas May 1 stocks averaged 32 percent of the April disappearance.

Cottonseed Meal

Data on the supply and disposition of cottonseed meal in table 3 are shown for the year beginning October. Demand analyses for high-protein feeds and for individual feeds are presented for this period, although for some feeds this does not conform to the usual marketing year. Cottonseed meal is usually shown for an August-July crop year. Production of cottonseed meal, by months, varies considerably more than does soybean meal. For 1946–55, index numbers of seasonal production of cottonseed meal varied from a low of 31 in July to a high of 177 in October, whereas soybean meal varied from a low of 74 in September to a high of 116 in January. This difference is due in part to the fact that cottonseed tends to deteriorate in storage, whereas soybeans can be stored for long periods with only minor losses. Apparent monthly disappearance shows a similar pattern.[4]

Feed uses.—Cottonseed meal accounted for an average of 28 percent of the total tonnage of oilseed meals fed in the 1950–54 period, and 19 percent of all high-protein feeds fed. About 2½ million tons were fed annually during this period, an increase of 32 percent above that fed in 1926–30. This increase resulted mainly from decreases in quantities exported and used for fertilizer. During 1926–30, an average of 78 percent of supplies were used for feed, whereas in 1950–54 over 90 percent were so utilized.

Jennings (*27*, p. 19) estimates that, in the year beginning October 1949, only 28 percent of the total cottonseed meal fed was utilized in formula feeds. About 51 percent was used by beef cattle, mainly in cake form for range feeding. Dairy cattle used 36 percent, and poultry, hogs, and other livestock the remaining 13 percent.

Cottonseed meal generally is sold with a guaranteed protein content of 41 percent, which may be adjusted by inclusion of hulls obtained in oilseed processing. At present, the hydraulic and screw press methods account for most of the production, but the solvent method is being used to an increasing extent. Currently, methods are used to remove the gossypol content, a yellow substance of the pigment glands of cottonseed. Gossypol gives unfavorable results, especially in poultry laying mashes, if cottonseed meal is used in large quantities. Much of the gossypol is changed into a less harmful substance called d-gossypol, or bound gossypol, in the heating that occurs in processing. Another method of removing gossypol is the so called gland-flotation process [see Pominski (*41*, p. 558–560)].

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[4] See pp. 129–34 for a description of seasonal patterns of production and disappearance for principal byproduct feeds. Data on supply, utilization, and prices of byproduct and feed grains are given in detail in Grain and Feed Statistics (*55*).

TABLE 3.—*Cottonseed meal: Supply and disposition, 1921–56*

Year beginning October	Supply				Disposition		
	Stocks, October 1 [1]	Production [2]	Imports [3]	Total	Exports	Use for— Fertilizer [4]	Use for— Feed
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1921	72.7	1,347.7		1,420.4	237.8	60.0	1,044.6
1922	78.0	1,453.7		1,531.7	200.8	75.0	1,208.5
1923	47.4	1,551.4		1,598.8	142.1	75.0	1,333.8
1924	47.9	2,233.6		2,281.5	472.7	160.0	1,559.4
1925	89.4	2,564.3		2,653.7	367.4	230.0	1,928.9
1926	127.4	2,923.0		3,050.4	493.6	300.0	2,148.2
1927	108.6	1,981.8		2,090.4	290.7	151.0	1,587.3
1928	61.4	2,332.0	14.3	2,407.7	309.7	93.0	1,922.5
1929	82.5	2,289.0	18.5	2,390.0	126.2	132.0	2,014.7
1930	117.1	2,065.6	.3	2,183.0	55.1	188.0	1,821.0
1931	118.9	2,499.2	1.1	2,619.2	218.9	458.0	1,740.4
1932	201.9	2,104.9	3.0	2,309.8	145.8	226.0	1,680.3
1933	257.7	1,834.5	5.0	2,097.2	63.1	165.0	1,700.5
1934	168.6	1,588.4	47.4	1,804.4	2.9	83.0	1,524.3
1935	194.2	1,791.2	5.7	1,991.1	10.6	137.0	1,718.3
1936	125.2	2,145.7	26.8	2,297.7	12.6	82.0	2,099.2
1937	103.9	2,759.1	4.6	2,867.6	88.5	187.0	2,332.7
1938	259.4	1,969.9	4.4	2,233.7	11.6	86.0	2,012.9
1939	123.2	1,775.0	33.0	1,931.2	4.9	68.0	1,761.7
1940	96.6	1,988.3	52.2	2,137.1	.9	101.0	1,861.9
1941	173.3	1,791.7	37.3	2,002.3	1.1	36.0	1,820.8
1942	144.4	2,014.9	46.8	2,206.1	1.7	78.0	2,077.5
1943	48.9	1,748.9	96.3	1,894.1	.6	42.0	1,790.0
1944	61.5	1,916.3	87.4	2,065.2	(5)	34.0	1,981.6
1945	49.6	1,409.8	47.6	1,507.0	(5)	19.0	1,432.6
1946	55.4	1,428.3	15.6	1,499.3	5.3	21.2	1,434.4
1947	38.4	2,015.6	13.8	2,067.8	9.6	30.0	1,953.0
1948	75.2	2,416.1	39.5	2,530.8	121.7	40.0	2,271.0
1949	98.1	2,496.6	104.8	2,699.5	123.6	40.0	2,382.4
1950	153.5	1,723.3	90.7	1,967.5	13.2	30.0	1,853.3
1951	71.0	2,524.2	201.9	2,797.1	35.0	30.0	2,650.1
1952	82.0	2,681.0	135.6	2,898.6	55.2	30.0	2,671.0
1953	[6] 142.4	3,014.4	69.8	3,226.6	66.1	30.0	2,925.5
1954	205.0	2,515.4	32.3	2,752.7	167.8	30.0	2,404.7
1955 [7]	150.2	2,628.1	59.4	2,837.7	155.7	30.0	2,511.1
1956 [7]	140.9	2,289.3	54.6	2,484.8	30.1	30.0	2,215.5

[1] Stocks at crushers' plants.
[2] Compiled from *Animal and Vegetable Fats and Oils* (*59*) and *Fats and Oils* (*60*).
[3] Not reported separately prior to January 1929.
[4] Meal used as fertilizer on cotton farms, as reported in *Cotton Production* (*58*) for crops through 1947, and estimated for subsequent years. Additional quantities are purchased for fertilizer, especially in earlier years, but no data are available.
[5] Less than 50 tons.
[6] Includes Commodity Credit Corporation stocks of 33.6 thousand tons, 4.4 thousand tons of which were at mills and 29.2 thousand at other positions.
[7] Preliminary.

Fertilizer.—Cottonseed meal formerly was used widely as fertilizer in producing areas. The fertilizing constituents of meal containing 41 percent protein are as follows: Phosphorus, 1.2 percent; nitrogen, 6.6 percent; and potassium, 1.5 percent. In 1926–30, 7 percent of supplies were used for fertilizer on farms of cotton producers, but in recent years the demand for feed and alternative supplies of fertilizer have been such that only about 1 percent is so used.

Exports.—Exports were fairly large in the 1920's—they amounted to more than 10 percent of supplies during 1926–30—but for most years since they have been of minor importance and usually less than imports.

Stocks.—Stocks of cottonseed meal are usually at a low point on September 1, when crushings of the new crop become heavy, and in recent years they have about equaled the previous month's utilization. Data on stocks for October 1, as shown in table 3, are considerably higher than for September 1.

Linseed Meal

Feed uses.—Linseed meal accounted for an average of 6 percent of the total tonnage of oilseed meals fed in 1950–54 and 4 percent of the total tonnage of high-protein feeds fed. Currently, production of meal is from domestically produced flaxseed only, and imports of meal as such have been small in most years, as shown in table 4. Before World War II, exports of meal were large in relation to total production; however, the flaxseed crushed in that period included large quantities imported from Argentina. This was crushed in plants located along the Atlantic seaboard. Much of the meal produced from imported flaxseed was then exported, mainly to European countries (see p. 11). Apparent disappearance for all years largely reflects meal produced from crushings of domestically produced flaxseed plus imported meal, although meal from imported flaxseed was used domestically in some years prior to 1940 for which domestic production of flaxseed was unusually low.

About 60 percent of the total quantity of linseed meal was utilized in formula feeds in the year beginning October 1949, according to estimates by Jennings (*27*, p. 19). Linseed meal is used widely as a feed for dairy cattle, both for its protein content and for other characteristics, such as palatability, conditioning and slightly laxative effects. In the feeding year 1949–50, about 60 percent of the total fed was utilized by dairy cattle, the remainder chiefly in beef cattle, sheep, and hog rations. Only minor quantities are used for poultry, as it is not considered a desirable source of protein in the poultry ration.

Linseed meal produced from domestic flaxseed by the screw-press process is generally sold with a guaranteed protein content of 34 percent, though meal sold on the San Francisco market most commonly is quoted at 28 percent. In recent years, solvent-process meal has become more important and is usually sold with a guaranteed protein content of 36 percent. Meal produced from imported Argentine flaxseed had a somewhat lower protein content.

Exports.—Exports of meal varied considerably in the period following World War II—they were negligible in 1952, 13 percent of supplies

TABLE 4.—*Linseed meal: Supply and disposition, 1921–56*

Year beginning October	Supply				Disposition	
	Stocks, October 1[1]	Production [2]	Imports	Total	Exports	Use for feed
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1921	--------	418.2	[3] 1.0	419.2	220.5	198.7
1922	--------	604.2	[3] 5.3	609.5	302.4	307.1
1923	--------	645.2	[3] 10.9	656.1	290.9	365.2
1924	--------	746.1	[3] 8.6	754.7	337.7	417.0
1925	--------	723.9	[3] 13.5	737.4	295.5	441.9
1926	--------	728.6	[3] 21.5	750.1	324.4	425.7
1927	--------	755.2	[3] 27.9	783.1	290.1	493.0
1928	--------	767.2	[3] 33.3	800.5	361.4	439.1
1929	--------	568.9	31.5	600.4	232.2	368.2
1930	--------	528.9	10.1	539.0	204.9	334.1
1931	--------	361.0	12.3	373.3	169.2	204.1
1932	--------	359.2	11.2	370.4	168.0	202.4
1933	--------	375.2	8.7	383.9	241.7	142.2
1934	--------	397.6	10.2	407.8	205.5	202.3
1935	--------	456.9	17.2	474.1	210.6	263.5
1936	--------	586.1	15.9	602.0	328.8	273.2
1937	--------	412.0	5.3	417.3	240.3	177.0
1938	--------	481.4	7.8	489.2	286.6	202.6
1939	--------	538.9	1.3	540.2	146.7	393.5
1940	--------	744.7	.6	745.3	4.8	740.5
1941	--------	902.2	.2	902.4	11.1	891.3
1942	--------	797.6	1.0	798.6	4.2	794.4
1943	--------	997.0	2.5	999.5	1.5	998.0
1944	--------	449.4	10.0	459.4	.7	458.7
1945	--------	562.4	1.2	563.6	.3	563.3
1946	--------	374.1	(4)	374.1	4.6	369.5
1947	--------	625.5	8.8	634.3	28.5	605.8
1948	[5] 17.5	686.8	8.1	712.4	54.0	619.8
1949	38.6	689.2	4.8	732.6	6.5	670.3
1950	55.8	729.8	1.0	786.6	29.2	731.9
1951	25.5	495.1	23.3	543.9	7.0	519.6
1952	17.3	457.7	26.4	501.4	(4)	478.2
1953	23.2	576.7	.6	600.5	34.2	526.5
1954	39.8	544.8	0	584.6	75.0	487.9
1955 [6]	21.7	581.7	0	603.4	152.6	439.0
1956 [6]	11.8	575.5	2.5	589.8	42.7	483.4

[1] Stocks at crushers' plants. Not reported prior to February 1949.
[2] Production from domestic and imported flaxseed. Prior to January 1949, derived from Census data on crushings; January 1949 to date, compiled from *Animal and Vegetable Fats and Oils (59)* and *Fats and Oils (60)*.
[3] Calendar year following.
[4] Less than 50 tons.
[5] February 1, 1949.
[6] Preliminary.

in 1954, and 25 percent in 1955. In the prewar period, imports of flaxseed exceeded domestic production in 14 out of 22 years during 1920–41, but large quantities of the meal produced from imported flaxseed were then exported to European countries. Table 5 shows the quantity of flaxseed imported, estimated meal production from these imports, and the quantity of meal exported for years beginning

July 1930–42. Imports of flaxseed have been negligible in recent years. If consideration is given to the 10-year period, 1930–39, before exports to Europe were cut off due to World War II, the general level of exports, for most years, corresponds to the estimated production of meal from imported flaxseed. Two years—1934 and 1936—stand out in sharp contrast; in these years the domestic crop was small owing to drought. Excluding 1934 and 1936, total exports averaged 89 percent of estimated production from imported flaxseed in the years 1930–39.

Imports.—Imports of meal amounted to about 5 percent of production in 1951 and 1952, but were not important in other post World War II years. During 1926–30, imports equaled an average of 6 percent of apparent disappearance, but were not important after 1936.

Stocks.—The crop year for flaxseed is July–June, but production of linseed meal, by months, is fairly uniform during the year. Data on stocks at crushers' plants have been reported by Census since February 1949. No distinct pattern of stocks is evident, although quantities are likely to be relatively high in fall and low in spring.

TABLE 5.—*Linseed meal: Estimated production from imported flaxseed as compared with exports, 1930–42*

Year beginning July	Estimated production from imported flaxseed			Exports of meal	
	Imports of flaxseed	Average yield per bushel crushed [1]	Estimated production of meal [2]	Total	Difference from estimated production from imported flaxseed
	Million bushels	*Pounds*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1930	7.8	36.8	144	153	9
1931	13.8	36.4	251	221	−30
1932	6.2	36.6	113	121	8
1933	17.9	35.6	319	273	−46
1934	15.3	35.4	271	190	−81
1935	15.4	35.8	276	230	−46
1936	26.1	35.5	463	281	−182
1937	17.9	35.4	317	278	−39
1938	18.7	35.3	330	268	−62
1939	13.2	35.6	235	214	−21
1940	11.2	35.6	199	4	−195
1941	23.3	35.6	415	7	−408
1942	6.3	35.7	112	10	−102

[1] Average for total crushings.
[2] Assuming yield of meal from imported flaxseed equal to average for total crushings.

Copra Meal

Copra meal is obtained from domestic crushings of imported copra and imports of meal as such—it is used almost entirely for feed. In recent years, imports of meal amounted to about 40 percent of total

TABLE 6.—*Copra meal: Supply and disposition, 1921–56*

Year beginning October	Supply				Disposition	
	Stocks, October 1 [1]	Production [2]	Imports	Total	Exports	Use for feed
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1921		45.5	[3] 20.4	65.9	4.7	61.2
1922		57.3	30.3	87.6	.8	86.8
1923		54.1	32.4	86.5	.8	85.7
1924		48.8	19.3	68.1	[4] .4	67.7
1925		66.1	22.9	89.0	(5)	89.0
1926		70.2	17.0	87.2	(5)	87.2
1927		79.3	16.1	95.4	(5)	95.4
1928		94.4	15.5	109.9	(5)	109.9
1929		93.2	16.3	109.5	(5)	109.5
1930		85.6	10.9	96.5	(5)	96.5
1931		70.6	4.6	75.2	(5)	75.2
1932		87.7	7.1	94.8	(5)	94.8
1933		89.2	[6] 28.0	117.2	(5)	117.2
1934		60.9	51.5	112.4	(5)	112.4
1935		78.4	49.3	127.7	(5)	127.7
1936		63.6	73.0	136.6	(5)	136.6
1937		77.7	39.9	117.6	(5)	117.6
1938		74.8	53.9	128.7	(5)	128.7
1939		90.3	88.5	178.8	(5)	178.8
1940		90.8	84.0	174.8	(5)	174.8
1941		48.1	22.6	70.7	(5)	70.7
1942		33.7	0	33.7	.1	33.6
1943		32.9	0	32.9	.1	32.8
1944		42.3	.1	42.4	.1	42.3
1945		67.6	1.7	69.3	0	69.3
1946		194.2	.5	194.7	5.2	189.5
1947		169.9	7.0	176.9	0	176.9
1948	[7] 5.5	128.2	44.3	177.9	0	170.6
1949	7.3	153.6	56.5	217.4	0	203.7
1950	13.7	148.8	66.1	228.6	.3	226.3
1951	2.0	121.5	103.8	227.3	(8)	220.4
1952	6.9	116.1	96.5	219.5	0	213.2
1953	6.3	116.0	79.8	202.1	(5)	196.5
1954	5.6	117.4	62.8	185.8	0	181.9
1955 [9]	3.9	112.2	44.9	161.0	0	159.7
1956 [9]	1.3	113.3	66.6	181.2	0	180.5

[1] Stocks at crushers' plants. Not reported prior to February 1949.
[2] Prior to January 1949, derived from census data on crushings; January 1949 to date, compiled from *Animal and Vegetable Fats and Oils (59) and Fats and Oils (60)*.
[3] Calendar year following.
[4] October–December. Not reported separately after December.
[5] Not separately reported.
[6] Imports for consumption beginning January 1934.
[7] February 1, 1949.
[8] Less than 50 tons.
[9] Preliminary.

disappearance. Feed use averaged 208,000 tons annually in 1950–54, or 2 percent of total oilseed meals fed. Copra meal is used mainly in dairy feeds. In addition to its value as a protein supplement, it has a high capacity for absorbing molasses and is sometimes used for this purpose in mixed feeds, as pointed out by Morrison (*37*, p. 574). Copra meal generally is sold with a guaranteed protein content of 20 percent. Meal production and utilization are mainly in California. Stocks tend to be relatively high in the fall, when production of meal is heavy. Stocks of copra meal at crushers' plants have been reported monthly since February 1949. October 1 stocks, together with production, foreign trade, and apparent use for feed, are shown in table 6.

Peanut Meal

Peanut meal, although amounting to only about 1 percent of total oilseed meals, is an important protein supplement in areas where produced. Production of meal during 1946–50 averaged 130,000 tons annually and about 20 percent of this quantity was exported. Production in 1954 dropped to 18,000 tons, of which 2,000 tons were exported, but production increased to 58,000 tons in the year beginning October 1955. These variations in production reflected changes in the Government support program for peanuts and diversion of peanuts to the Commodity Credit Corporation for crushing for oil and meal. Imports have been small in most years, as shown in table 7. Stocks of peanut meal are usually small, reflecting in part a tendency for the meal to become rancid if stored in warm, moist climates. It is considered an excellent protein feed for all classes of livestock and generally is sold with a guaranteed protein content of 45 percent. Peanut meal is used almost entirely in formula feeds.

Tankage and Meat Scraps

Meat byproducts for livestock feed are obtained mainly from operations of meat-packing plants and slaughter houses, though some is recovered as meat scraps from further marketing operations. A limited quantity of rendering-plant tankage is also produced, but a large proportion of this is used as fertilizer. There are two methods of processing meat byproducts for feed. The older is a steam rendering of fatty residues – the so-called wet-rendering method. The product is called digester tankage, meat meal tankage, or feeding tankage. Products of a dry-rendering method of more recent development, or a combination of tankage produced by the two methods, also are sold under these names. Products that contain more than 4.4 percent phosphorus must be designated as "tankage with bone." Tankage prices commonly are quoted for 60 percent protein content, or in terms of a price per unit of protein.

When meat scraps are produced by the dry-rendering method, meat byproducts are cooked in an open steam-jacketed vessel to evaporate the moisture content. The product is called meat scraps, meat meal, or dry-rendered tankage; and when the phosphorus content exceeds 4.4 percent the product must be designated as "meat and bone scraps" or something similar. Bone meal, also sold separately, is of value for its mineral content. A thorough discussion of the various processing methods and byproducts is given in "By-products of the Meat Packing Industry" (*25*) and in Morrison (*37*). Prices of meat scraps commonly are quoted at 50 or 55 percent protein content, or in terms of a price per unit of protein.

TABLE 7.—*Peanut meal: Supply and disposition, 1921–56*

Year beginning October	Supply				Disposition	
	Stocks, October 1 [1] [2]	Production [2]	Imports	Total	Exports	Use for feed
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1921		23.2	[3] 0	23.2	[4] 7.3	15.9
1922		6.9	[3] 2.9	9.8	.3	9.5
1923		3.9	[3] 2.3	6.2	(5)	6.2
1924		15.2	[3] .2	15.4	(5)	15.4
1925		10.7	[3] 1.4	12.1	(5)	12.1
1926		7.7	[3] 2.1	9.8	(5)	9.8
1927		13.3	[3] 9.1	22.4	(5)	22.4
1928		12.2	[3] 5.3	17.5	(5)	17.5
1929		26.8	[3] 8.3	35.1	(5)	35.1
1930		15.4	[3] 2.2	17.6	(5)	17.6
1931		11.4	[3] 2.3	13.7	(5)	13.7
1932		14.6	[3] 2.3	16.9	(5)	16.9
1933		10.2	[6] 1.2	11.4	(5)	11.4
1934		43.8	3.5	47.3	(5)	47.3
1935		45.9	1.9	47.8	(5)	47.8
1936		57.0	9.6	66.6	(5)	66.6
1937		48.2	2.1	50.3	(5)	50.4
1938	2.0	65.0	10.5	77.5	(5)	74.8
1939	2.7	30.3	9.7	42.7	(5)	38.1
1940	4.6	133.5	7.6	145.7	(5)	137.2
1941	8.5	57.3	7.1	72.9	(5)	70.7
1942	2.2	103.0	4.6	109.8	.1	108.6
1943	1.1	108.7	3.6	113.4	.1	110.9
1944	2.4	98.6	2.5	103.5	.4	102.5
1945	.6	87.4	3.1	91.1	.1	90.0
1946	1.0	122.0	1.1	124.1	26.2	97.5
1947	.4	123.0	3.1	126.5	3.7	122.1
1948	.7	116.7	.9	118.3	21.1	96.1
1949	1.1	138.7	6.2	146.0	48.9	94.2
1950	2.9	151.3	1.1	155.3	24.0	129.8
1951	1.5	94.5	5.2	101.2	2.2	98.6
1952	.4	42.0	3.5	45.9	(7)	44.3
1953	1.6	63.2	.7	65.5	1.4	62.8
1954	1.3	18.5	0	19.8	1.6	17.7
1955 [8]	.5	58.3	0	58.8	30.0	26.9
1956 [8]	1.9	62.5	0	64.4	15.0	46.2

[1] Stocks at crushers' plants. Not reported prior to 1938.
[2] Compiled from *Peanuts, Stocks and Processing* (*56*).
[3] Calendar year following.
[4] January–September.
[5] Not separately reported.
[6] October–December quarter estimated.
[7] Less than 50 tons.
[8] Preliminary.

Meat scraps and tankage are used mainly in hog and poultry rations, with about 80 percent of the total fed being in formula feeds in 1949–50, as indicated by Jennings (*27*, p. 19). These feeds are valued both for their high protein content and for a feed nutrient referred to as the "animal protein factor." An important component was isolated in 1948—vitamin B–12; synthetic production of this vitamin for animal feeds has increased markedly since that time. Vitamin B–12 is now used in most manufactured poultry and other livestock feeds, as reported in a recent survey by the Agricultural Marketing Service (*7*).

Production of meat scraps and tankage have been reported since 1944. Estimated production of these feeds for earlier years, as given in table 8, is based mainly on levels of livestock slaughter. Production of meat scraps accounted for 77 percent of total production of tankage and meat scraps for feed in 1950–54. Additional quantities of meat byproducts unsuitable for animal feeding are used for fertilizer and are reported separately. Annual average imports of tankage for feed use amounted to 22,000 tons in 1950–54, or 10 percent of total supplies of tankage.

Tankage and meat scraps accounted for 8 percent of the total tonnage of high-protein feeds fed in 1950–54. Meat scraps are preferable to tankage for poultry feeds and have a somewhat better quality protein, although the percentage content is slightly lower than for top-grade tankage.

Fish Byproducts

Fish byproducts used for animal feed amounted to an annual average of 399,000 tons in 1950–54, or 3 percent of total high-protein feeds fed. Domestic production of meal averaged 240,000 tons; imports, 116,000 tons; and production of condensed fish solubles and homogenized condensed fish, 42,000 tons on a solids basis. Exports of fish meal have been negligible in recent years (table 9).

These fish byproducts generally are high in protein content and quality. Menhaden meal, which represented 68 percent of domestic production during 1950–54, generally is quoted with a guaranteed protein content of 60 percent. Production of this meal is concentrated along the Atlantic and Gulf coasts. Other important meals produced in this area include herring (protein content about 70 percent), white fish or ground-fish (protein content about 60 percent), and crab meal, which has a lower protein content. On the Pacific coast and Alaska, tuna (protein content about 58 percent), mackeral, sardine (protein content about 67 percent), and herring meal account for most of the production. Important sources of imported meal are Canada, Norway, Angola, Peru, and Denmark. Minor quantities of fish solubles also are imported, mainly from Canada and Norway.

Production of condensed fish solubles, reported since 1944, increased from a level of 6,300 tons, on a solids basis, in that year to 45,600 tons for the year beginning October 1954. These solubles have a protein content of 30–35 percent, or 60–70 percent on a solids equivalent basis, but are especially valuable for their content of B-complex vitamins.

TABLE 8.—*Meat scraps and tankage: Production, imports, and total supply, 1926–56*

Year beginning October	Production [1]			Imports [3]	Total supply available for feeding
	Meat scraps	Tankage	Total [2]		
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1926			610	[4] 30	640
1927			612	[4] 43	655
1928			606	[4] 24	630
1929			586	34	620
1930			588	37	625
1931			570	30	600
1932			600	35	635
1933			614	21	635
1934			528	32	560
1935			573	69	642
1936			565	69	634
1937			568	40	608
1938			585	82	667
1939			651	77	728
1940			693	109	802
1941			779	56	835
1942			847	30	877
1943			906	69	975
1944	568.7	203.3	772.0	20.3	792.3
1945	566.5	162.9	729.4	15.4	744.8
1946	552.5	174.0	726.5	14.0	740.5
1947	594.7	194.9	789.6	33.8	823.4
1948	610.3	206.3	816.6	37.4	854.0
1949	611.0	202.5	813.5	28.1	841.6
1950	640.5	217.7	858.2	24.0	882.2
1951	698.3	213.8	912.1	34.3	946.4
1952	781.1	231.5	1,012.6	19.6	1,032.2
1953	835.4	224.2	1,059.6	18.5	1,078.1
1954	[5] 1,042.4	[5] 278.8	[5] 1,321.2	12.6	1,333.8
1955	[5] 1,229.1	[5] 316.5	[5] 1,545.6	11.3	1,556.9
1956 [6]	[5] 1,181.6	[5] 297.1	[5] 1,478.7	6.1	1,484.8

[1] A small upward adjustment has been made in these series for the years 1944–53 from the data given in *Meat Scraps and Tankage Production (58)*.

[2] Data for 1926–43 are rough estimates based on livestock slaughter.

[3] Tankage for feed. Data for 1926–42 include imports of dried blood.

[4] Based on calendar year following. Assumes 65 percent for feed and 35 percent for fertilizer.

[5] Data have been revised, by extending coverage to include additional plants and specifying that meat scraps and meal should include poultry byproduct meal (feather meal not included). Data for the years prior to 1954 are not comparable with the revised estimates for 1954, 1955, and 1956. Unrevised data for 1954 on which the analyses were based are as follows: Meat scraps 838.1; tankage 222.1; total 1,060.2; imports 12.6; and total supply available for feeding 1,072.8.

[6] Preliminary.

Production of homogenized condensed fish amounted to 14,500 tons on a solids basis for 1954, the first year for which production was reported separately. Production is reported for Massachusetts and Rhode Island only, and the product is sold by a limited number of companies.

Fish byproducts are used largely in poultry and hog manufactured feeds. Feed use increased from an annual average of 127,000 tons in 1926–30 to 399,000 tons in 1950–54. Both imports and domestic production contributed to this increase. Minor quantities of fish are used in canned animal food. In addition, crushed shell and grit are produced for poultry feed. Crushed oyster shell production amounted to 373,000 tons in 1953.

TABLE 9.—*Fish byproducts: Supply and disposition, 1921–56*

Year beginning October	Supply						Disposition	
	Production [1]				Imports [4]	Total supply	Exports	Use for feed
	Meal and scrap [2]	Condensed fish solubles (solids basis) [2]	Homogenized condensed fish (solids basis) [3]	Total				
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1921	[5] 90.4	--------	--------	[5] 90.4	--------	--------	--------	[6] 95
1922	[5] 69.0	--------	--------	[5] 69.0	--------	--------	--------	[6] 80
1923	[5] 56.9	--------	--------	[5] 56.9	--------	--------	--------	[6] 70
1924	[5] 76.6	--------	--------	[5] 76.6	--------	--------	--------	[6] 95
1925	[5] 69.4	--------	--------	[5] 69.4	--------	--------	--------	[6] 95
1926	[5] 71.9	--------	--------	[5] 71.9	--------	--------	--------	[6] 100
1927	[5] 84.5	--------	--------	[5] 84.5	--------	--------	--------	[6] 113
1928	[5] 119.6	--------	--------	[5] 119.6	--------	--------	--------	[6] 148
1929	121.3	--------	--------	121.3	--------	--------	--------	[6] 151
1930	80.6	--------	--------	80.6	[5] 43.5	124.1	[5] 3.0	121.1
1931	84.2	--------	--------	84.2	25.0	109.2	[5] 2.6	106.6
1932	108.7	--------	--------	108.7	29.1	137.8	7.3	130.5
1933	156.8	--------	--------	156.8	38.1	194.9	25.1	169.8
1934	178.0	--------	--------	178.0	34.4	212.4	26.0	186.4
1935	200.0	--------	--------	200.0	45.5	245.5	9.8	235.7
1936	206.4	--------	--------	206.4	70.2	276.6	2.1	274.5
1937	175.5	--------	--------	175.5	47.3	222.8	1.5	221.3
1938	194.8	--------	--------	194.8	51.6	246.4	.7	245.7
1939	190.7	--------	--------	190.7	47.2	237.9	.4	237.5
1940	226.9	--------	--------	226.9	36.0	262.9	.3	262.6
1941	184.2	--------	--------	184.2	23.3	207.5	.2	207.3
1942	194.9	--------	--------	194.9	7.6	202.5	(7)	202.5
1943	190.3	[6] 6.3	--------	196.6	5.9	202.5	(7)	202.5
1944	217.7	[6] 6.0	--------	223.7	4.7	228.4	(7)	228.4
1945	202.5	4.3	--------	206.8	5.8	212.6	(7)	212.6
1946	189.8	4.6	--------	194.4	7.9	202.3	.5	201.8
1947	204.3	7.5	--------	211.8	24.3	236.1	.2	235.9
1948	218.2	23.1	--------	241.3	47.0	288.3	(5)	288.3

See footnotes at end of table.

TABLE 9.—*Fish byproducts: Supply and disposition, 1921–56*—Con.

Year beginning October	Supply						Disposition	
	Production [1]							
	Meal and scrap [2]	Condensed fish solubles (solids basis) [2]	Homogenized condensed fish (solids basis) [3]	Total	Imports [4]	Total supply	Exports	Use for feed
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1949	240.9	25.9	-------	266.8	57.3	324.1	(5)	324.1
1950	234.4	[9] 25.3	(9)	259.7	72.6	332.3	(8)	332.3
1951	223.7	[9] 33.7	(9)	257.4	180.2	437.6	(8)	437.6
1952	235.1	[9] 39.9	(9)	275.0	114.7	389.7	(8)	389.7
1953	255.4	40.5	[6] 14.5	310.4	127.5	437.9	(8)	437.9
1954	253.4	45.6	11.3	310.3	84.7	395.0	(8)	395.0
1955 [10]	300.8	49.7	14.1	364.6	97.3	461.9	(8)	461.9
1956 [10]	259.8	47.8	14.1	321.7	81.8	403.5	(8)	403.5

[1] Compiled from *Fish Meal and Oil* (68) and other data provided by the Fish and Wildlife Service.

[2] Beginning January 1945, includes reported monthly production by firms which normally account for 90 to 95 percent of total production, plus calendar year (following) data for "other" production.

[3] Converted to solids basis using a conversion factor of 50 percent. Data for 1943–53 based on calendar year reported production adjusted to year beginning October, based on distribution of monthly production reported for 1954 and 1955.

[4] Includes cod-liver cake and meal prior to 1941. Beginning 1954, includes condensed fish solubles, solids basis.

[5] Calendar year following.

[6] Partly estimated.

[7] Less than 50 tons.

[8] Data on exports after 1948 include other minor feeds; fish meal exports are assumed to be negligible.

[9] Production of homogenized condensed fish included with condensed fish solubles.

[10] Preliminary.

Commercial and Noncommercial Milk Products

Commercial milk products, which include dried and concentrated skim milk and buttermilk and dried, concentrated and condensed whey, amounted to an average of 120,000 tons in 1950–54, excluding Commodity Credit Corporation sales of these products for feed. This compares with 89,000 tons fed in 1926–30. Dried and concentrated skim milk, which formerly accounted for over half of the tonnage of commercial milk products, has decreased to less than 10 percent of the total. Quantities of dried and concentrated buttermilk fed have not shown a marked trend, whereas the quantity fed of dried whey has increased sharply and in 1950–54 accounted for more than 65 percent of the total commercial milk products fed to livestock.

Estimated use of commercial and noncommercial milk products fed to livestock are given in table 10.

Noncommercial milk products include skim milk, buttermilk, whole milk, and whey fed on farms. An average of 1,248,000 tons, dry-weight equivalent, was fed annually in 1950–54. This represents a decrease of 35 percent from the average quantity fed in 1926–30, reflecting the decreased quantity of skim milk and buttermilk available on farms that resulted from increased commercial production of milk products. Use of whole milk and whey for feed has trended upward over this period.

Dried skim milk and buttermilk contain a protein content of about 30 percent and are considered excellent sources of protein and riboflavin for poultry, calf, and pig feeds. Dried whey has a higher riboflavin content than dried skim milk and buttermilk, but has a protein content of only about 12 percent. It is used largely in poultry rations (see Morrison (*87*, p. 595)). Commercial milk products are utilized mainly in manufactured feeds. An estimate for the year beginning October 1949 indicates that of the total noncommercial milk byproducts fed, 52 percent went to hogs, 41 percent to dairy cattle, and 7 percent to poultry.

TABLE 10.—*Milk byproducts: Estimated commercial and noncommercial products fed, 1926–56*

Year beginning October	Commercial [1]	Noncommercial [2]	Total	Year beginning October	Commercial [1]	Noncommercial [2]	Total
	1,000 tons	*1,000 tons*	*1,000 tons*		*1,000 tons*	*1,000 tons*	*1,000 tons*
1926	65	1,970	2,035	1942	95	1,710	1,805
1927	80	1,820	1,900	1943	105	1,665	1,770
1928	90	1,925	2,015	1944	105	1,610	1,715
1929	105	1,925	2,030	1945	100	1,520	1,620
1930	105	2,005	2,110	1946	120	1,475	1,595
1931	110	2,060	2,170	1947	90	1,415	1,505
1932	115	2,080	2,195	1948	110	1,400	1,510
1933	120	1,955	2,075	1949	115	1,400	1,515
1934	125	1,880	2,005	1950	100	1,350	1,450
1935	125	1,830	1,955	1951	110	1,265	1,375
1936	135	1,750	1,885	1952	115	1,250	1,365
1937	140	1,840	1,980	1953	[3] 395	1,215	1,610
1938	135	1,835	1,970	1954	[3] 170	1,160	1,330
1939	155	1,810	1,965	1955 [4]	155	1,120	1,275
1940	150	1,880	2,030	1956 [4]	150	1,100	1,250
1941	130	1,780	1,910				

[1] Includes dried and concentrated skim milk and buttermilk, dried whey and, beginning January 1954, concentrated and condensed whey.

[2] Includes the dry-weight equivalent of skim milk, buttermilk, whole milk, and whey fed on farms where produced.

[3] Commodity Credit Corporation sales of nonfat milk products for the years beginning October 1953 and 1954 amounted to 260 and 27 thousand tons, respectively.

[4] Preliminary.

Gluten Feed and Meal and Corn Oil Meal

The principal feed byproducts obtained in the wet-process milling of corn are gluten feed, gluten meal, and corn oil meal. Sales of gluten feed and meal averaged 944,000 tons annually in 1950–54, of which approximately 25 percent is believed to have sold as gluten meal. Corn oil meal sales averaged 50,000 tons annually for this period. Trends in sales of these products are shown in table 11.

TABLE 11.—*Gluten feed and meal and corn oil meal: Sales of the Corn Refiners Industry, 1926–56* [1]

Year beginning October	Gluten feed and meal	Corn oil meal	Total	Year beginning October	Gluten feed and meal	Corn oil meal	Total
	1,000 tons	*1,000 tons*	*1,000 tons*		*1,000 tons*	*1,000 tons*	*1,000 tons*
1926	621.0	36.0	657.0	1942	928.9	62.7	991.6
1927	667.4	39.7	707.1	1943	844.3	55.9	900.2
1928	644.0	30.6	674.6	1944	863.5	54.0	917.5
1929	602.6	25.9	628.5	1945	797.4	58.3	855.7
1930	484.1	21.1	505.2	1946	1,035.0	62.2	1,097.2
1931	521.5	17.4	538.9	1947	792.8	60.2	853.0
1932	528.9	24.3	553.2	1948	813.6	52.7	866.3
1933	588.5	19.3	607.8	1949	863.2	52.4	915.6
1934	454.9	19.2	474.1	1950	1,009.3	56.5	1,065.8
1935	558.2	24.6	582.8	1951	855.4	55.7	911.1
1936	516.4	30.8	547.2	1952	904.1	50.7	954.8
1937	547.4	21.5	568.9	1953	954.0	47.3	1,001.3
1938	590.9	27.1	618.0	1954	995.7	38.6	1,034.3
1939	613.6	28.0	641.6	1955 [2]	1,034.1	38.4	1,072.5
1940	760.8	37.0	797.8	1956 [2]	977.7	32.8	1,010.5
1941	980.4	48.8	1,029.2				

[1] Compiled from reports of Price Waterhouse and Company for monthly sales, 1932–54, and shipments, 1955 to date. Data for earlier years reported for calendar year only; estimated sales for October year based on seasonal pattern of corn grindings by wet-process milling.
[2] Preliminary.

Corn gluten meal usually is sold with a guaranteed protein content of 41 percent. The protein is not considered as high in quality as that of soybean meal, for example, and is not used as the principal protein supplement in poultry and hog rations. However, when produced from yellow corn, it has a relatively high carotene (pro-vitamin A) content in the yellow pigmentation substance called xanthophyll. Thus, it is valued as an ingredient in poultry rations. Gluten meal also is used extensively in dairy rations.

Corn gluten feed generally is sold with a guaranteed protein content of 25 percent or lower. It consists of corn bran (hulls), which gives it a bulky consistency desirable for dairy rations, plus gluten meal which is added to raise the protein content. Gluten feed may also contain corn oil meal, obtained from processing the corn germ, and sometimes corn solubles which are recovered from the steepwater in which the corn is soaked in the wet-process method.

Corn oil meal, as noted above, is mixed with gluten feed and also sold as such. It has a protein content approximately equal to that of gluten feed, but contains a higher percentage of fat. The protein quality is somewhat better than that of gluten feed and meal (see Morrison (*37* p. 489)).

Brewers' Dried Grains

The major feed byproduct of the fermentation industry is brewers' grains. Barley and corn are the major grains used in the fermentation industry, although some rice and wheat is used. These byproduct feeds generally are sold as dried grains, though a limited quantity is sold as wet grains in areas near processing plants. Production trends of brewers' dried grains are shown in table 12. Yearly average production was 231,000 tons in 1950–54. During 1920–33, production was limited by law to cereal beverages with less than 0.5 percent alcohol content. The protein content of brewers' dried grains averages about 25 percent, with a fat content of about 6.4 percent. These byproducts are fed mainly to dairy cattle.

Other fermentation byproducts used for feed include brewer's dried yeast and malt sprouts. The feeding value of brewers' dried yeast

TABLE 12.—*Brewers' dried grains: Production, stocks, and disappearance, 1921–56*

Year beginning October	Stocks, October 1 [1]	Production [2]	Disappearance [3]	Year beginning October	Stocks, October 1 [1]	Production [2]	Disappearance [3]
	1,000 tons	*1,000 tons*	*1,000 tons*		*1,000 tons*	*1,000 tons*	*1,000 tons*
1921		12	12	1939	4.5	101.0	100.2
1922		10	10	1940	5.3	117.2	115.7
1923		9	9	1941	6.8	168.7	173.6
1924		10	10	1942	1.9	232.4	230.4
1925		9	9	1943	3.9	230.7	231.0
1926		8	8	1944	3.6	217.4	216.8
1927		8	8	1945	4.2	211.9	212.9
1928		7	7	1946	3.2	228.3	229.5
1929		7	7	1947	2.0	233.0	228.3
1930		6	6	1948	6.7	232.4	233.1
1931		5	5	1949	6.0	233.0	233.3
1932		18	18	1950	5.7	238.9	240.8
1933		70	70	1951	3.8	222.6	223.4
1934		84	84	1952	3.0	228.7	224.3
1935	4.7	98.9	97.0	1953	7.4	226.5	227.9
1936	6.6	110.2	114.1	1954	6.0	238.4	238.4
1937	2.7	103.8	102.5	1955 [4]	6.0	243.5	245.7
1938	4.0	104.1	103.6	1956 [4]	3.8	236.5	236.3

[1] Stocks at producers' plants. Not reported prior to 1935.

[2] Compiled from *Brewers' Dried Grains* (*47*), 1935 to date. Data for prior years estimated from production of cereal beverages containing less than ½ of 1 percent alcohol, for years beginning July 1921–32; and, for 1933–34, including production of fermented malt liquors.

[3] Assumed to be used entirely for feed.

[4] Preliminary.

is due mainly to its content of B-complex vitamins, although in addition it contains a protein content of about 47 percent. It is used mainly in poultry rations. Production data are not reported, but for the year 1944, a level of 7,000 tons is indicated in unpublished data on file in the Department of Agriculture. Malt sprouts, obtained from the production of malt, generally are mixed with brewers' dried grains, but also are sold as such. Production data are not currently available. Malt sprouts are fed mainly in mixed dairy rations and brewers' dried yeast is used mainly in poultry and hog mixed feeds.

Distillers' Dried Grains and Solubles

The principal feed byproducts from the distilling industry include distillers' dried grains, with or without solubles, and distillers' dried solubles. Corn is the major grain used in the distilling industry, but rye, barley, wheat, and sorghum grains also are important. During 1942–44, large quantities of wheat and sorghum grains also were used in the production of alcohol and distilled spirits. The dried grains vary as to protein content depending on the grains included in the distilling process. Distillers' dried grains from corn commonly have a protein content of about 28 percent; from rye, 18 percent; and from wheat they vary from about 28 percent to 46 percent for a high-protein dried grain. These grains also are sold including dried solubles, and are referred to as "dark" grains as distinguished from "light" grains, or those without solubles. Dried solubles also are sold as such. Production of dried solubles and dried grains with solubles in 1950–54 accounted for about three-fourths of total production (table 13).

Dried solubles have a protein content approximately equal to that of the respective distillers' dried grain, but are especially important as a source of B-complex vitamins. Some dried solubles are used in the manufacture of vitamins and antibiotics; this use amounted to 2,400 tons in 1953–54 (see Hall (*16*, p. 19)). Stillage, or the watery residue from the distilling process, also is used in the production of vitamins and antibiotics.

Dried solubles and distillers' dried grains with solubles are especially valuable in poultry and hog rations as a source of vitamins. The protein is not considered as high quality for poultry and hogs, but is satisfactory when fed to dairy and beef cattle (see Morrison (*37*, p. 620)). Distillers' dried grains without solubles are fed mainly to dairy cattle and do not contain the B-complex vitamins important to poultry and hog nutrition.

OTHER BYPRODUCT FEEDS

Byproduct feeds with a protein content of less than 20 percent are included in this classification. Wheat millfeeds account for the largest tonnage in this group and may be considered as a medium-protein feed, containing an average of about 17 percent protein. Alfalfa meal also is a medium-protein byproduct feed. Byproduct feeds having less than 15 percent protein content include dried and molasses beet pulp, rice millfeeds, screenings, and molasses. Oat

TABLE 13.—*Distillers' dried grains and dried solubles: Stocks, production, and disappearance, 1921–56*

Year beginning October	Stocks,[1] October 1	Production [2]					Disappearance [3]
		Distillers' dried grains			Distillers' dried solubles	Grand total	
		Without solubles	With solubles	Total			
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1921	-----	-----	-----	-----	-----	42	42
1922	-----	-----	-----	-----	-----	60	60
1923	-----	-----	-----	-----	-----	65	65
1924	-----	-----	-----	-----	-----	78	78
1925	-----	-----	-----	-----	-----	95	95
1926	-----	-----	-----	-----	-----	86	86
1927	-----	-----	-----	-----	-----	79	79
1928	-----	-----	-----	-----	-----	93	93
1929	-----	-----	-----	-----	-----	90	90
1930	-----	-----	-----	-----	-----	79	79
1931	-----	-----	-----	-----	-----	71	71
1932	-----	-----	-----	-----	-----	59	59
1933	-----	-----	-----	-----	-----	110	110
1934	-----	-----	-----	-----	-----	160	160
1935	4.4	-----	-----	240.4	-----	240.4	243.5
1936	1.3	-----	-----	230.4	-----	230.4	231.2
1937	.5	-----	-----	149.4	-----	149.4	148.9
1938	1.0	-----	-----	148.6	0.5	149.1	149.1
1939	1.0	-----	-----	163.1	.5	163.6	163.2
1940	1.4	-----	-----	205.9	.6	206.5	206.1
1941	1.8	-----	-----	341.7	3.7	345.4	345.3
1942	1.9	-----	-----	339.3	17.6	356.9	356.1
1943	2.7	285.4	131.2	416.6	27.3	443.9	444.1
1944	2.5	352.6	195.4	548.0	85.5	633.5	634.3
1945	1.7	133.4	88.6	222.0	105.9	327.9	326.0
1946	3.6	157.4	148.7	306.1	105.2	411.3	409.8
1947	5.1	130.1	147.8	277.9	73.2	351.1	352.9
1948	3.3	86.9	188.2	275.1	57.8	332.9	334.0
1949	2.2	91.3	188.6	279.9	85.2	365.1	351.7
1950	15.6	199.5	288.6	488.1	146.0	634.1	641.5
1951	8.2	65.0	184.6	249.6	82.6	332.2	338.7
1952	1.7	40.0	116.2	156.2	29.5	185.7	185.6
1953	1.8	68.8	122.1	190.9	54.4	245.3	243.8
1954	3.3	67.0	130.7	197.7	52.2	249.9	250.9
1955 [4]	2.3	67.6	166.4	234.0	51.9	285.9	286.2
1956 [4]	2.0	59.1	185.3	244.4	45.9	290.3	289.9

[1] Stocks at producers' plants. Not reported prior to 1935.
[2] Compiled from *Distillers' Dried Grains* (*48*), 1935 to date; data for prior years estimated from production of alcohol and distilled spirits for year beginning July.
[3] Assumed to be used entirely for feed.
[4] Preliminary.

middlings and feeding oat meal have a protein content of about 16 percent, and oat millfeeds, about 6 percent. An estimated quantity of oat millfeeds is included with miscellaneous byproduct feeds, as production data are not available on a current basis.

Wheat Millfeeds

Total wheat millfeeds fed in 1950–54 averaged 4,749,000 tons annually, or 21 percent of the total byproducts fed. Quantities available for feeding have been relatively stable since 1921, although current quantities average about 5 percent less than in 1926–30. Exports have been negligible (see in table 14). Imports of wheat millfeeds are mainly from Canada and total imports averaged 243,000 tons yearly in 1950–54. Millfeeds produced from wheat imported in-bond are included in the domestic production data reported by Census (*62*) and amounted to roughly 50,000 tons annually in 1950–54.

TABLE 14.—*Wheat millfeeds: Supply and disposition, 1926–56*

Year beginning October	Supply			Disposition	
	Production [1]	Imports	Total	Exports	Domestic disappearance
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1926	4, 783. 7	99. 7	4, 883. 4	6. 4	4, 877. 0
1927	4, 894. 0	148. 9	5, 042. 9	22. 9	5, 020. 0
1928	4, 907. 9	203. 3	5, 111. 2	32. 5	5, 078. 7
1929	4, 951. 8	178. 0	5, 129. 8	19. 0	5, 110. 8
1930	4, 743. 5	228. 1	4, 971. 6	25. 4	4, 946. 2
1931	4, 375. 6	51. 2	4, 426. 8	57. 3	4, 369. 5
1932	4, 286. 6	99. 9	4, 386. 5	18. 2	4, 368. 3
1933	4, 173. 0	117. 1	4, 290. 1	22. 9	4, 267. 2
1934	4, 122. 8	298. 3	4, 421. 1	8. 5	4, 412. 6
1935	4, 524. 5	226. 4	4, 750. 9	11. 6	4, 739. 3
1936	4, 410. 9	265. 6	4, 676. 5	6. 6	4, 669. 9
1937	4, 466. 4	11. 5	4, 477. 9	29. 6	4, 448. 3
1938	4, 545. 0	239. 1	4, 784. 1	22. 1	4, 762. 0
1939	4, 262. 8	392. 5	4, 655. 3	14. 1	4, 641. 2
1940	4, 348. 0	415. 9	4, 763. 9	2. 2	4, 761. 7
1941	4, 346. 0	187. 4	4, 533. 4	. 8	4, 532. 6
1942	4, 629. 0	110. 4	4, 739. 4	. 5	4, 738. 9
1943	4, 905. 0	60. 1	4, 965. 1	2. 0	4, 963. 1
1944	5, 437. 0	54. 3	5, 491. 3	2. 9	5, 488. 4
1945	4, 781. 0	115. 4	4, 896. 4	. 4	4, 896. 0
1946	6, 054. 0	49. 0	6, 103. 0	4. 9	6, 098. 1
1947	5, 420. 0	65. 7	5, 485. 7	5. 3	5, 480. 4
1948	4, 795. 0	128. 7	4, 923. 7	6. 9	4, 916. 8
1949	4, 580. 0	181. 1	4, 761. 1	6. 9	4, 754. 2
1950	4, 535. 0	289. 0	4, 824. 0	6. 4	4, 817. 6
1951	4, 660. 0	319. 9	4, 979. 9	5. 7	4, 974. 2
1952	4, 460. 0	261. 1	4, 721. 1	1. 4	4, 719. 7
1953	4, 425. 0	245. 0	4, 670. 0	1. 1	4, 668. 9
1954	4, 477. 0	99. 5	4, 576. 5	9. 3	4, 567. 2
1955 [2]	4, 429. 0	79. 4	4, 508. 4	21. 1	4, 487. 3
1956 [2]	4, 540. 0	108. 0	4, 648. 0	25. 6	4, 622. 4

[1] Compiled from *Flour Milling Products* (*62*). Production data for calendar years 1940–44 are estimates developed in cooperation with the former United States Bureau of Agricultural Economics, now in the Agricultural Marketing Service.
[2] Preliminary.

Wheat millfeeds from spring wheat include the following, with the comparable millfeeds from winter wheat indicated in parentheses: Bran (bran); standard middlings (brown shorts); flour middlings (grey shorts); and red dog (white shorts). Wheat bran, consisting of the outer coating of the wheat kernel, accounts for approximately half of the total of all wheat millfeeds. In general, the millfeeds from spring wheat contain a slightly higher protein and fat content and a lower fiber content than comparable millfeeds from winter wheat. Bran obtained chiefly from hard spring wheat, for example, contains 17.9 percent protein, 4.9 percent fat, 10.0 percent fiber, and 68.2 percent total digestible nutrients (see Morrison (*37*, p. 1128)). Bran is an important feed for dairy cattle, breeding and young stocks of beef cattle, and for poultry rations.

Standard middlings and brown shorts consist of fine particles of bran and the wheat germ and have a higher protein and digestible nutrient content and a lower fiber content than bran. These millfeeds are fed mainly to swine, calves, and poultry, but the protein obtained is not considered a direct substitute for certain high-protein feeds.

Wheat red dog and white shorts consist of the aleurone layer, or that directly under the bran coats, plus small quantities of flour and fine bran particles. Red dog has an average of 18.2 percent protein, 3.6 percent fat, 2.6 percent fiber and 85.6 percent total digestible nutrients (see Morrison (*37*, p. 1130)). These millfeeds account for about 10 percent of the total obtained in processing but often are combined with standard middlings (brown shorts) and sold as wheat flour middlings (grey shorts). Both wheat red dog and standard middlings and the comparable millfeeds from winter wheat are considered as excellent feeds for young pigs and calves. In addition to these millfeeds, relatively small quantities are sold as wheat mixed feeds, a combination of wheat bran and flour middlings (grey shorts), and as wheat germ meal. If the wheat germ is removed, the resulting wheat millfeed contains a much lower vitamin E content. Screenings are sold separately and also are included with the various millfeeds, but feeds thus sold are labeled to this effect.

For the 1949-50 crop year, Jennings (*27*) estimates that over 80 percent of wheat millfeeds were used in formula feeds and that over half of the total fed was utilized by poultry. Dairy cattle utilize about a fourth of the total, and the remainder is fed to other livestock.

Alfalfa Meals

Total production of alfalfa meal has shown a sharp upward trend since 1926–30; in that period an annual average of 320,000 tons was produced. In 1950–54, 1,237,000 tons were produced. 81 percent of which was dehydrated alfalfa meal. Sun-cured alfalfa meal accounted for a major part of total production until 1946–47, but since that time it has decreased in relative and absolute importance (see table 15). Meal is sold as alfalfa leaf meal, alfalfa meal, and alfalfa stem meal—these vary in fiber and protein content. Both dehydrated and sun-cured meals are commonly quoted with a guaranteed protein content of 17 percent and with a specified vitamin A (carotene) content, but the vitamin content tends to vary considerably. Dehydrated alfalfa meal and dehydrated leaf meal, as Morrison (*37*, p. 346) points out "are usually twice as high in carotene as the products made from field-cured hay and they are also somewhat higher in riboflavin. However, dehydrated alfalfa meal and leaf meal have practically no vitamin D, while alfalfa meal and leaf meal from field-cured hay have considerable. . . . This lack of vitamin D in dehydrated products is not of importance in feeding poultry. . . . (since the form of this vitamin in

TABLE 15.—*Alfalfa meal: Stocks, production, and apparent disappearance, 1926–56*

Year beginning October	Stocks, October 1 [1] [2]			Production [2]			Disappearance [3]
	Dehydrated	Sun-cured	Total	Dehydrated	Sun-cured	Total	
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1926						[4] 250.0	250.0
1927						374.2	374.2
1928						350.7	350.7
1929						374.7	374.7
1930						248.3	248.3
1931						178.4	178.4
1932						193.9	193.9
1933						233.9	233.9
1934						204.9	204.9
1935						284.0	284.0
1936						380.0	380.0
1937						370.0	370.0
1938						410.0	410.0
1939						440.0	440.0
1940						470.0	470.0
1941						590.0	590.0
1942						679.9	679.9
1943	33.6	4.6	38.2	317.3	454.5	771.8	733.5
1944	64.4	12.1	76.5	450.5	485.0	935.5	921.7
1945	85.6	4.7	90.3	577.9	675.2	1,253.1	1,191.8
1946	140.3	11.3	151.6	637.7	378.5	1,016.2	1,039.7
1947	120.3	7.8	128.1	743.8	366.2	1,110.1	999.4
1948	229.3	9.3	238.7	761.0	308.5	1,069.6	1,122.0
1949	171.9	14.4	186.2	868.8	277.2	1,146.0	1,093.7
1950	226.6	11.9	238.5	905.5	260.6	1,165.1	1,217.7
1951	180.6	5.3	185.9	1,045.7	280.4	1,286.1	1,177.9
1952	286.6	7.5	294.1	862.5	208.1	1,070.6	1,043.0
1953	314.1	7.6	321.7	1,045.9	219.2	1,265.1	1,209.5
1954	371.3	6.0	377.3	1,178.5	223.6	1,402.1	1,324.5
1955	450.4	4.5	454.9	998.2	176.7	1,174.9	1,242.9
1956 [5]	381.6	5.3	386.9	1,032.7	172.1	1,204.8	1,152.0

[1] Stocks at processors' plants. Not available prior to 1943.
[2] Compiled from *Alfalfa Meal Production* (*52*). Production, by type, not reported separately prior to 1943.
[3] Assumed to be consumed entirely for domestic livestock feeding. Disappearance assumed equal to production, 1926–42.
[4] Partly estimated.
[5] Preliminary.

alfalfa meal is not well utilized by poultry" (p. 343)). "However, in using the dehydrated products as a vitamin supplement for swine, it must be borne in mind that they do not supply vitamin D, like field-cured hay does."

Production of dehydrated alfalfa meals is highly seasonal, with 70 percent of the total produced between June and September in the period 1950–54. Stocks on October 1, as shown in table 15, tend to be close to a seasonal high. Index numbers of seasonal production are shown in table 72, page 131. Production of sun-cured alfalfa meals shows less seasonal variation than dehydrated meals, and stocks usually are relatively small.

Alfalfa meals are fed mainly to poultry, though they can be used by various kinds of livestock. For the 1949–50 feeding year, Jennings (27) estimates that over 90 percent of these meals were used in formula feeds.

Dried and Molasses Beet Pulp

Apparent disappearance of dried and molasses beet pulp averaged 455,000 tons annually in 1950–54. Imports accounted for 12 percent of this quantity. Production of molasses beet pulp, as compared with dried beet pulp, currently accounts for 73 percent of domestic production as compared with 59 percent in 1926–30. Total production increased from 165,000 tons annually in 1926–30 to 400,000 tons in 1950–54 (see table 16).

Dried and molasses beet pulp are fed mainly to dairy cattle and, to some extent, to beef cattle. Dried beet pulp and molasses beet pulp have approximately equal feeding values. The protein content is relatively low, averaging about 9 percent for dried beet pulp, and these feeds are valued mainly for the carbohydrate feeding value, palatability, and bulky composition.

Rice Millfeeds

Production of rice millfeeds averaged 254,000 tons in 1950–54, compared with 94,000 tons annually in 1926–30 (see table 17). Rice bran is the most important rice feed byproduct, though limited quantities of brewers' rice and rice meal also are fed. The bran is fed mainly to dairy cattle and contains a protein content of about 12 percent, 13 percent fat, and 12 percent fiber. In addition to the good quality protein supplied, it is rich in the vitamins thiamine and niacin.

Industrial Molasses

The use of molasses for feed averaged 2,024,000 tons annually for 1951–55, as compared with 715,000 tons fed annually in 1935–39. This increase resulted from larger mainland production and imports and inshipments, plus a decrease in use of molasses for certain industrial and other uses (see table 18). Of the total mainland production of industrial molasses in 1951–54, 54 percent was cane and refiners' blackstrap, 28 percent beet molasses (exclusive of that in molasses beet pulp), 12 percent hydrol, and 6 percent citrus molasses. About 90 percent of inshipments and imports are cane molasses.

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TABLE 16.—*Beet pulp: Production, imports, and apparent disappearance, 1926–56*

Year beginning October	Production [1]			Imports	Apparent disappearance
	Dried pulp	Molasses pulp	Total		
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1926	78	74	152	31	183
1927	76	89	165	18	183
1928	75	64	139	26	165
1929	48	111	159	52	211
1930	60	150	210	75	285
1931	75	99	174	19	193
1932	134	116	250	12	262
1933	134	141	275	7	282
1934	92	130	222	27	249
1935	74	125	199	29	228
1936	73	157	230	60	290
1937	51	166	217	29	246
1938	105	219	324	15	339
1939	98	175	273	13	286
1940	110	182	292	19	311
1941	102	176	278	16	294
1942	134	149	283	11	294
1943	62	92	154	----------	154
1944	99	72	171	4	175
1945	95	121	216	2	218
1946	127	153	280	5	285
1947	91	203	294	3	297
1948	76	199	275	57	332
1949	96	204	300	52	352
1950	113	293	406	37	443
1951	88	231	319	77	396
1952	67	253	320	65	385
1953	100	339	439	58	497
1954	164	351	515	39	554
1955 [2]	108	352	460	18	478
1956 [2]	106	432	536	14	550

[1] Data relate to year in which beets are harvested, as reported in *Sugar Beets* (*45*) and *Crop Production* (*46*). From 1940 to date based on data from Sugar Division, Commodity Stabilization Service. Production of moist beet pulp is excluded.

[2] Preliminary.

Molasses is utilized mainly in formula feeds, and for the year beginning October 1949, Jennings (*27*) estimates that about 85 percent of total molasses was so utilized. It is fed mainly to dairy and beef cattle, but is sometimes used in mixed feeds for poultry and hogs. Molasses is used, also, as a preservative for grass silage, and in recent years large quantities have been used for direct on-farm feeding, mainly to beef cattle.

Cane molasses and blackstrap, which are obtained as byproducts from refining sugar cane, are valued as carbohydrate feeds and are considered highly palatable to livestock. The protein content is about 2.9 percent, with a digestible protein content of zero (see Morrison (*37*, p. 1124)). Cane molasses is a good source of niacin and pantothenic acid.

Beet molasses has about the same carbohydrate feeding value as cane molasses and a protein content of about 8 percent. It is more laxative than cane molasses and should be fed in limited quantities. Citrus molasses also contains about as much sugar as cane molasses. If fed in limited quantities, it has a feeding value equivalent to that of cane molasses. Hydrol, a byproduct of manufacture of corn sugar from corn, is somewhat higher in sugar content than cane molasses, but also has a negligible protein content and is considered to have a feeding value about equal to that of cane molasses.

TABLE 17.—*Rice millfeeds and miscellaneous byproduct feeds: Estimated use for feed, 1926–56*

Year beginning October	Rice mill-feeds [1]	Miscellaneous byproduct feeds [2]	Year beginning October	Rice mill-feeds [1]	Miscellaneous byproduct feeds [2]
	1,000 tons	*1,000 tons*		*1,000 tons*	*1,000 tons*
1926	93.0	2,000	1942	144.7	1,600
1927	100.0	2,000	1943	139.0	1,600
1928	99.0	2,000	1944	149.6	1,600
1929	88.0	2,000	1945	154.8	1,700
1930	87.0	2,000	1946	166.1	2,000
1931	79.0	2,000	1947	177.6	2,000
1932	97.0	2,000	1948	190.4	2,300
1933	[3] 83.0	2,000	1949	213.7	2,550
1934	88.9	2,000	1950	187.0	2,400
1935	88.5	2,000	1951	243.3	2,750
1936	108.0	2,000	1952	263.1	3,350
1937	124.3	2,000	1953	273.2	3,600
1938	124.1	2,000	1954	303.0	3,800
1939	119.9	2,000	1955 [4]	237.7	3,500
1940	124.8	2,000	1956 [4]	257.0	3,400
1941	124.5	2,000			

[1] Compiled from reports of the Agricultural Marketing Service, for 1933 to date. For prior years, based on data on rice milled (1930–32) or rice sold (1926–29).

[2] Estimated quantities used for feed, including molasses, hominy feed, oat millfeeds, and screenings. Data for molasses, 1935 to date, obtained from sources noted in footnote 3, table 18, and estimated from various sources for prior years. Data for hominy feed and oat millfeeds for recent years based on the 1947 and 1954 Census of Manufactures (*63*) reported production and interpolated for intercensal year. For prior years, hominy feed production estimated from quantities of "corn processed into meal, hominy, flour, and breakfast cereal" as reported by the Census, and interpolated for inter-censal years. Oat millfeeds estimated from quantities of "oats milled" as reported by the Census of Manufactures. The series also includes a rough allowance for screenings based on trends in milling and processing.

[3] Partly estimated.

[4] Preliminary.

TABLE 18.—*Industrial molasses: Supply and disposition, 1935–56*

Year	Supply			Disposition			
					Domestic [3]		
	Mainland production [1]	Imports and inshipments [2]	Total	Exports	Industrial and food	Livestock feed, expressed in— Gallons	Livestock feed, expressed in— Tons [4]
	Million gallons	*Million gallons*	*Million gallons*	*Million gallons*	*Million gallons*	*Million gallons*	*1,000 tons*
1935	87. 2	318. 2	405. 4	8. 1	248. 1	149. 2	877
1936	98. 1	282. 0	380. 1	19. 5	245. 6	115. 0	676
1937	102. 2	360. 4	462. 6	12. 5	273. 2	176. 9	1, 039
1938	107. 8	224. 8	332. 6	11. 9	216. 7	104. 0	611
1939	101. 1	239. 7	340. 8	19. 9	257. 6	63. 3	372
1940	90. 3	330. 5	420. 8	7. 4	301. 0	112. 4	660
1941	101. 6	465. 2	566. 8	6. 9	390. 4	169. 5	996
1942	95. 0	263. 5	358. 5	. 4	307. 6	50. 5	297
1943	104. 0	211. 2	315. 2	. 2	273. 1	41. 9	246
1944	126. 0	354. 6	480. 6	. 1	418. 2	62. 3	366
1945	126. 9	190. 7	317. 6	1. 6	249. 7	66. 3	390
1946	122. 2	142. 7	264. 9	1. 0	185. 5	78. 4	461
1947	127. 7	224. 4	352. 1	. 6	223. 6	127. 9	751
1948	147. 6	294. 3	441. 9	8. 2	209. 1	224. 6	1, 320
1949	141. 4	300. 9	442. 3	7. 8	233. 9	200. 6	1, 179
1950	147. 4	316. 1	463. 5	9. 3	221. 0	233. 2	1, 370
1951	152. 8	319. 9	472. 7	4. 1	219. 9	248. 7	1, 461
1952	148. 7	386. 3	535. 0	5. 4	229. 2	300. 4	1, 765
1953	149. 1	491. 0	640. 1	14. 8	271. 4	353. 9	2, 079
1954	149. 4	425. 0	574. 4	10. 5	157. 8	406. 1	2, 386
1955	156. 0	427. 4	628. 4	10. 9	198. 3	419. 2	2, 463
1956	150. 0	435. 5	585. 5	13. 5	195. 9	376. 1	2, 210

[1] Includes cane, refiners' blackstrap, beet, citrus and hydrol.
[2] Includes imports, mainly from Cuba, and from the Dominican Republic, Mexico, and other countries; and inshipments from Hawaii and Puerto Rico.
[3] Estimated utilization as shown in *Industrial Molasses* (*69*, pp. 15, 17) for 1945 to date, and in *Sugar Reports* (*65*) for earlier years. No changes in stocks are considered.
[4] Converted from gallons to tons assuming 1 gallon equals 11.75 pounds.

Hominy Feed

Hominy feed is obtained as a byproduct in the dry-milling of corn to obtain corn meal, hominy grits, and breakfast foods. It consists of the corn bran and part of the kernel containing starch. The average fat content is 6.9 percent and the protein content, 11.2 percent (see Morrison (*37*, p. 1120)). However, the fat and protein content vary, depending on the use of the corn germs. The germ sometimes is separated out and the resulting feed, corn germ meal, is sold as such; it contains 19.8 percent protein and 7.8 percent fat (see Morrison (*37*, p. 1118)).

Production of hominy feed was first reported in the Census of Manufactures for 1947. A special report on Grain-Mill Products (*63*,

p. 12), based on the 1954 Census of Manufactures, indicates total shipments and interplant transfers of "hominy feed and byproducts of dry corn milling (for animal feed)" of 529,000 tons in 1947, and 634,000 tons for 1954. This report also indicates that 346,000 tons of hominy feed and meal were used in the prepared feeds industry in 1947 and 414,000 tons in 1954.

Morrison (*37*, p. 484) indicates "hominy feed resembles ground corn in composition and is about equal to it in feeding value for the various classes of stock. It is usually slightly higher than corn in protein, and it contains more fiber than corn and therefore is somewhat more bulky. Unless part of the fat has been removed from the germs, hominy feed will be considerably richer than corn in fat and will furnish a slightly greater amount of total digestible nutrients." Yellow hominy feed has a slightly higher protein content than white hominy feed.

Oat Millfeed

Oat millfeed, or oat feed, is obtained as a byproduct in the manufacture of oatmeal for human consumption. Morrison (*37*, p. 496) indicates "about 84 percent is oat hulls and 16 percent consists of fragments from the oat kernels (called oat middlings) and the fuzzy material covering the kernels (called oat shorts or oat dust) . . . . Oat millfeed of the usual grade is nearly as high in fiber as average grass hay and contains less protein than grass hay of good quality . . . . Oat millfeed can also be used as a substitute for part of the grain ordinarily fed to dairy cows, beef cattle, sheep, and horses. A small percentage can even be added to swine rations with satisfactory results. Because of the high fiber content and the relatively low amounts of total nutrients and net energy, oat millfeed is usually worth only about 30 to 40 percent as much as corn grain, when used as a partial grain substitute. This value takes into consideration the larger amount of protein supplements needed when oat millfeed is fed." The protein content of oat millfeeds is indicated at 5.6 percent, whereas oat middlings average 15.9 percent. Feeding oatmeal or rolled oats, without hulls, contain an average protein content of about 16 percent.

The production of oat millfeeds first was reported in the Census of Manufactures for 1947. A special report on Grain-Mill Products (*68*, p. 12), based on the 1954 Census of Manufactures, indicates total shipments and interplant transfers of "oat millfeed and other byproducts of oats" equaled 237,000 tons in 1947, and 316,000 tons in 1954.

Screenings

Screenings are obtained in cleaning wheat and other small grains at the farm before sale and before milling for human use. Morrison (*37*, p. 577) points out "screenings consist of small, broken, or shrunken kernels of grain, wild oats and wild buckwheat, smaller weed seeds, and more or less chaff and broken pieces of stem. . . . The best grades of screenings, consisting chiefly of broken and shrunken kernels of grain, with wild oats and other palatable weed seeds, resemble oats in composition. Such screenings, when ground, may nearly equal grain in feeding value. Light, chaffy screenings are much higher in fiber and consequently lower in value. Some poor-quality screenings resemble straw more than grain in composition and value. . . . Flaxseed screenings are usually considerably higher in fat than wheat screenings due to immature or broken flaxseeds. However, they are also generally higher in fiber."

Screenings are mixed with millfeeds to some extent, but are sold as such for use in mixed feeds, mainly for dairy cattle and are used as a concentrate. Morrison (*37*, p. 578) indicates "ground screenings can be used satisfactorily as one-fourth or somewhat more of the concentrate mixture for dairy cows, beef cattle or swine. The best results are secured when screenings are fed extensively to fattening lambs, especially in the wheat growing areas in the West. Often they are used as the only concentrate." Good grade grain screenings average 15.8 percent protein content and 9.2 percent fiber, and screenings of poorer quality have much lower protein content and higher fiber content (see Morrison (*37*, p. 1126)).

Production data on screenings are not available. In addition to domestic production, screenings are imported, mainly from Canada. Since data are not available on the use of screenings in feed, the series on miscellaneous feed includes an allowance for trends in this item. No data are available on the actual quantity fed in recent years.

THE PREPARED FEEDS INDUSTRY

Nutritional research in poultry and livestock feeding indicates the advantages of carefully balanced rations for growth and production. Much broiler and other poultry concentrates are fed as commercially prepared feeds, in which it is possible to include such additives as vitamins and antibiotics. These additives are included in hog and other livestock supplements also. The high-protein byproduct feeds are important ingredients in these rations and are used to obtain the desired level of protein and to balance the grains which are the major source of energy in the ration.

This section presents a brief review of the use of byproduct feeds in various livestock rations and in commercially prepared feeds for the year beginning October 1949. Shipments of prepared feeds, by kind, are given for 1947 and 1954, based on data from the Census of Manufactures. Also trends in the "Prepared Animal Feeds" industry are indicated for the Census years 1927–54, and the value of shipments, by regions, is given for 1954.

FEEDS USED, 1949–50

The most comprehensive study available of the use of individual feeds by type of livestock and as formula feeds or fed as such is the report by Jennings (*27*) for the year beginning October 1949. This report gives a detailed description of the estimation procedures and sources of data employed. In general, the estimated level of formula feeds fed in 1949–50 was based on data on total shipments and interplant transfers, as given in the 1947 Census of Manufactures, but these data were adjusted upward to allow for estimated production not reported by the Census, such as prepared feeds manufactured in retail and wholesale establishments. Also these data were adjusted to the 1949–50 feeding year, based on production of manufactured feeds reported by the American Feed Manufacturers Association.

Use of individual byproduct feeds and grains, by kind of livestock, in formula feeds and in total concentrates fed are summarized in table 19. These data are obtained from Jennings (*27*) and are estimated, at least in part, in many instances but do provide useful indications of the utilization of feeds.

TABLE 19.—*Byproduct feeds and feed grains: Use in formula feeds and total fed, by type of livestock, year beginning October 1949* [1]

Kind of feed	Fed to specified type of livestock					
	Poultry [2]		Dairy cattle		Hogs	
	In formula feeds [3]	Total	In formula feeds	Total	In formula feeds	Total
Byproduct feeds:						
High-protein:	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
Oilseed meals:						
Soybean	1, 756	1, 914	577	890	1, 170	1, 312
Cottonseed	45	105	460	858	65	128
Linseed	88	91	206	391	65	88
Peanut and copra	214	216	43	43	10	10
Animal and fish:						
Milk products, noncommercial	------	89	------	544	------	676
Other	686	800	------	------	224	330
Grain proteins:						
Gluten feed and meal	326	340	428	536	------	------
Brewers' and distillers' dried grains	------	------	373	534	------	------
Total high-protein	3, 115	3, 555	2, 087	3, 796	1, 534	2, 544
Other:						
Millfeeds and hominy	2, 828	3, 293	1, 108	1, 641	337	387
Alfalfa meal	657	731	65	65	82	93
Dried beet and citrus pulp	------	------	247	360	------	------
Molasses	110	110	686	686	57	57
Total other	3, 595	4, 134	2, 106	2, 752	476	537
Total byproduct feeds	6, 710	7, 689	4, 193	6, 548	2, 010	3, 081
Grains:						
Corn, excluding silage	4, 879	15, 207	777	8, 848	101	35, 902
Oats	1, 060	3, 842	543	5, 216	------	6, 593
Barley	599	863	146	886	------	1, 006
Sorghum grains	519	1, 064	23	189	------	441
Wheat and rye fed	1, 151	3, 345	102	313	19	285
Total grains	8, 208	24, 321	1, 591	15, 452	120	44, 227
Grand total	14, 918	32, 010	5, 784	22, 000	2, 130	47, 308

See footnotes at end of table.

TABLE 19.—*Byproduct feeds and feed grains: Use in formula feeds and total fed, by type of livestock, year beginning October 1949* [1]—Continued

Kind of feed	Fed to specified type of livestock				Total fed	
	Beef cattle		Other livestock [4]			
	In formula feeds	Total	In formula feeds	Total	In formula feeds	Total
Byproduct feeds:						
High-protein:	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
Oilseed meals:						
Soybean	60	90	307	307	3,870	4,513
Cottonseed	80	1,218	12	75	662	2,384
Linseed	36	87	12	13	407	670
Peanut and copra	7	7	20	20	294	296
Animal and fish:						
Milk products, noncommercial						1,309
Other			59	59	969	1,189
Grain proteins:						
Gluten feed and meal			50	50	804	926
Brewers' and distillers' dried grains	50	50	1	1	424	585
Total high-protein	233	1,452	461	525	7,430	11,872
Other:						
Millfeeds and hominy	162	162	607	607	5,042	6,090
Alfalfa meal	67	67	119	119	990	1,075
Dried beet and citrus pulp		114		11	247	485
Molasses	231	420	111	118	1,195	1,391
Total other	460	763	837	855	7,474	9,041
Total byproduct feeds	693	2,215	1,298	1,380	14,904	20,913
Grains:						
Corn, excluding silage	62	7,600	1,042	6,318	6,861	73,875
Oats	88	786	232	1,896	1,923	18,333
Barley	16	203	94	220	855	3,178
Sorghum grains			47	80	589	1,774
Wheat and rye fed			74	74	1,346	4,017
Total grains	166	8,589	1,489	8,588	11,574	101,177
Grand total	859	10,804	[5] 2,787	9,968	26,478	122,090

[1] Data adapted from Jennings (*27*). Includes noncommercial milk products.
[2] Includes feed consumption only for poultry on farms.
[3] Adjusted to include ingredients in formula feeds fed to poultry on farms. Estimated by assuming that percentage of ingredients in off-farm poultry feeds equals the ratio of the tonnage of mash (scratch feed) fed to off-farm poultry to the tonnage of mash (scratch) fed to farm poultry.
[4] Includes sheep, horses and mules, all poultry, and livestock in cities, and livestock other than the kinds listed on farms.
[5] Includes 1,167,000 tons of poultry mash and 95,000 tons of scratch for poultry in cities; 62,000 tons of sheep feed; 401,000 tons of horse and mule feed; and 1,062,000 tons of feed for other livestock.

For the year beginning October 1949, these data indicate that 22 percent of the tonnage of all concentrates fed was utilized in formula feeds. A similar comparison by groups of feeds indicates 11 percent for feed grains, 63 percent for all high-protein feeds, and 83 percent for "other" byproduct feeds. However, for all high-protein feeds other than cottonseed meal and noncommercial milk, 83 percent of the tonnage fed was in formula feeds.

The relative importance of formula feeds as an outlet for the various individual feeds also is shown by this study. The following tabulation shows, for this year, the percentages of the stated feeds utilized in formula feeds:

	Percent
High-protein feeds:	
Oilseed meals:	
Soybean	86
Cottonseed	28
Linseed	61
Peanut and copra	99
Animal and fish byproducts, excluding noncommercial milk	81
Gluten feed and meal	87
Brewers' and distillers' dried grains	72
Other byproduct feeds:	
Millfeeds and hominy	83
Alfalfa meal	92
Dried beet and citrus pulp	51
Grains:	
Corn, excluding silage	9
Oats	10
Barley	27
Sorghum grains	27
Wheat and rye fed	34

Table 20 shows the total quantity of high-protein feeds fed to each kind of livestock and the percentage in formula feeds.

TABLE 20.—*High-protein feeds: Amount fed and percentage in formula feeds, by type of livestock, year beginning October 1949* [1]

Type of livestock	Amount fed	
	Total	Percentage in formula feeds
	1,000 tons	*Percent*
Dairy cattle	3,796	55
Poultry on farms	3,555	88
Hogs	2,544	60
Beef cattle	[2] 1,452	16

[1] Summarized from data in table 19.
[2] Mostly cottonseed cake and meal used in range feeding.

SHIPMENTS OF PREPARED POULTRY AND LIVESTOCK FEEDS

Shipments of prepared poultry and livestock feeds amounted to 25.5 million tons in 1954, according to data reported by the Bureau of the Census (*63*). These data, as shown in table 21, refer to ship-

TABLE 21.—*Prepared poultry and livestock feeds: Total shipments, including interplant transfers, quantity and value, 1947 and 1954* [1]

Kind of feed	1947			1954		
	Quantity		Value	Quantity		Value
	Actual	Percentage of total		Actual	Percentage of total	
	1,000 tons	*Percent*	*Million dollars*	*1,000 tons*	*Percent*	*Million dollars*
Poultry feeds:						
Scratch grains	1, 755			1, 054		83. 5
Mash and pellets that contain under 25 percent protein:						
Chicken:						
Layer and breeder	4, 318			4, 885		432. 2
Starter	960			1, 137		108. 1
Grower	1, 173			1, 341		121. 3
Broiler	1, 522			3, 314		321. 3
Turkey	547			934		90. 6
Other	612			773		64. 1
Supplements and concentrates that contain over 25 percent protein:						
Chicken	} 832			1, 163		129. 5
Turkey				394		40. 9
Not specified by kind	[2] 207			[3] 400		37. 2
Total	11, 926	57. 6		15, 395	60. 4	1, 428. 7
Livestock feeds:						
Dairy, with protein content of—						
Under 25 percent	4, 664			3, 830		302. 1
Over 25 percent	608			837		77. 4
Total	5, 272	25. 4		4, 667	18. 3	379. 5
Beef and range cattle	436	2. 1		1, 504	5. 9	116. 4
Pig and hog, with protein content of—						
Under 25 percent	771			913		85. 7
Over 25 percent	707			1, 377		153. 4
Total	1, 478	7. 1		2, 290	9. 0	239. 1
Horse and mule	534	2. 6		340	1. 3	25. 1
Other [4]	828	4. 0		824	3. 2	65. 8
Not specified by kind	[2] 240	1. 2		[3] 465	1. 8	39. 7
Total	8, 788	42. 4		10, 090	39. 6	865. 6
Total poultry and livestock	20, 714	100. 0	1, 856. 0	25, 485	100. 0	2, 294. 3

See footnotes on opposite page.

ments and interplant transfers of establishments classified in the "Prepared Animal Feeds" industry and other producers of these feeds. However, it does not include prepared feeds manufactured in retail and wholesale establishments. Comparable data for 1947 indicate total shipments and interplant transfers of 20.7 million tons, thus giving an increase of 23 percent from 1947 to 1954. Commercially prepared feeds increased sharply from an estimated 11 million tons in 1939, and also in relation to total concentrates fed and total feeds purchased, as indicated in the Feed Situation (*54*, p. 24)

Shipments of poultry feeds, including scratch feeds, amounted to 15.4 million tons in 1954, or 60 percent of the total poultry and livestock feeds shipped. Broiler mash shipments were more than double the 1947 level, whereas scratch feeds were 40 percent less. In total, poultry feed shipments in 1954 were 29 percent above those in 1947.

Dairy feeds accounted for 18 percent of total shipments and interplant transfers of prepared feeds in 1954, as compared with 25 percent of the total in 1947. Shipments in 1954 were 89 percent of the 1947 tonnage. Supplements containing over 25 percent protein content increased by 38 percent, whereas feeds containing less than 25 percent protein, which accounted for 82 percent of total dairy feeds in 1954, decreased by 18 percent.

Prepared feeds for beef and range cattle shipped in 1954 amounted to 1.5 million tons as compared with 250,000 tons in 1947. In 1954, these feeds accounted for 6 percent of total shipments.

Shipments of prepared pig and hog feed in 1954 amounted to 2.3 million tons, 55 percent above the 1947 level. Most of this increase was in supplements that contain over 25 percent protein, which accounted for 60 percent of the total for pigs and hogs in 1954.

Prepared horse and mule feeds declined from 1947 to 1954, reflecting the reduction in numbers of work animals.

In addition to the poultry and livestock feeds shown in table 21, the Census report (*63*) indicates quantities of dog and cat food of various types, and value data for prepared animal feeds not specified by kind. Dog and cat foods that are most likely to include byproduct feeds, that is, biscuits, pellets and meal, amounted to 474,000 tons in 1954 as compared with 340,000 tons in 1947. For the prepared animal feeds not specified by kind, over 600,000 tons were shipped in 1954, as compared with 530,000 tons in 1947. These figures were computed from value data, assuming that the average value per ton for these feeds equaled that for total poultry and livestock feeds.

Value data also were reported for Vitamin B–12 and antibiotic supplements. A delivered cost for these items, reported for the Pre-

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[1] Data are from 1954 Census of Manufactures report on Grain-Mill Products (*63*), and include shipments and interplant transfers by both producers in the "Prepared Animal Feeds" industry and other producers of the stated primary products. These data exclude prepared feeds manufactured in retail and wholesale establishments.

[2] Estimate (by Census) based on value.

[3] Estimated by assuming that the 447 thousand tons of poultry and livestock feeds "not specified by kind" for 1947 was distributed between these groups as for 1954.

[4] Includes rabbit and other small animal feeds, except dog and cat food.

pared Animal Feeds industry, amounted to $23.5 million, or roughly 1 percent of the value of all poultry and livestock prepared feeds. Further discussion of these additives to livestock rations is given in this bulletin on pages 65-66.

Questions exist as to the completeness of coverage of total prepared feeds by the Census of Manufactures, even after allowing for the fact that retail and wholesale establishments are excluded. The American Feed Manufacturers Association publishes estimates of total production of manufactured feeds which, in recent years, are well above 30 million tons. A survey of feedstuffs purchased by farmers in 1955, conducted by the Department of Agriculture in cooperation with the Bureau of the Census (*61*), indicates a total for prepared feeds of 24 million tons. This excludes quantities purchased for poultry and other livestock not on farms and thus would be lower than the total manufactured. Differences between the data from these three sources cannot be explained at present.

TRENDS IN THE INDUSTRY

Data are shown in table 22 by census years during 1927–54 on the number of establishments, average number of employees (total and production workers), value added by manufacture, and value of

TABLE 22.—*Prepared animal feeds industry: Number of establishments and employees, Census years 1927–54* [1]

Year	Establishments		Average employees for year	
	20 or more employees	Total	Production workers	Total
	Number	*Number*	*Thousands*	*Thousands*
1927		447	7.6	11.4
1929		750	10.2	14.4
1931		796	8.4	(2)
1933		710	8.8	11.3
1935		942	11.6	15.4
1937		1,126	14.4	19.2
1939		1,383	15.4	24.2
1947	670	2,688	40.1	55.2
1954	685	2,292	41.3	59.9

[1] Data obtained from Census of Manufactures report on Grain-Mill Products (*68, p. 3*). Data for years prior to 1927 are not comparable since they do not include data for manufacturers of prepared feeds who grind the grain consumed. These data are reported for each establishment as a whole. Aggregates of such data for an industry reflect not only the primary activities of the establishments in that industry, but also their activities in the manufacture of secondary products and receipts for their other activities (contract work on materials owned by others, repair work, etc.). This fact should be taken into account in comparing these *industry statistics* with *product statistics* which show the shipments by all producers of primary products of the industry. [The value of total shipments, including interplant transfers, in the product statistics for 1954 was 2,843 million dollars and for 1947 was 2,213 million dollars.]

[2] Not available.

products shipped. These data refer to establishments whose primary products are prepared feeds, whereas data in table 21 are for total shipments of prepared feeds by all manufacturing establishments.

The number of establishments in 1947 was twice that in 1939 and six times that in 1927. In 1954, the total number decreased by about 15 percent from the 1947 level, although establishments with 20 or more employees increased from 670 to 684.

Another indication of trend in the prepared feed industry is given by data on the number of employees. The average number of production workers employed in 1947 was 2.6 times that in 1939 and 5.3 times that in 1927. In contrast to the trend in numbers of establishments from 1947 to 1954, the number of production workers increased by about 3 percent, and total numbers of employees increased by about 9 percent. Trends in average number of employees do not adequately reflect changes in the quantity manufactured since technology of production has changed considerably during this period. The increase in quantity shipped from 1947 to 1954, described previously, relates to producers in the "prepared feeds industry" and to other producers of these products, and thus it is not possible to quantify these changes in productivity per worker.

PRODUCTION BY REGIONS

The 1954 Census data (*63*) indicate quantities of shipments and interplant transfers for 33 States, and totals for 9 regions. The regional data are shown in table 23. New York is the leading State in value of shipments, and second to California in the number of production workers. California is the second ranking producer of

TABLE 23.—*Prepared animal feeds: Specified data by regions, 1954*

Region	Establishments		Production workers		Value of shipments	
	20 or more employees	Total	Average number for year	Percentage of total	Total	Percentage of total
	Number	*Number*	*Thousands*	*Percent*	*Million dollars*	*Percent*
New England	26	47	1.3	3	127	5
Middle Atlantic	70	269	5.0	12	388	14
East North Central	108	400	7.6	18	543	20
West North Central	135	493	8.7	21	507	19
South Atlantic	98	313	5.1	12	314	12
East South Central	47	175	3.3	8	213	8
West South Central	88	232	4.6	11	243	9
Mountain	27	116	1.3	3	55	2
Pacific	85	247	4.4	10	312	11
Total	684	2,292	41.3	100	2,702	100

1954 Census of Manufactures, report on Grain-Mill Products (*63*).

prepared feeds, according to the 1954 Census data. The North Central States, however, accounted for 39 percent of the total value of shipments and numbers of production workers.

MAJOR PRODUCING AND PROCESSING AREAS

The location of production of byproduct feeds influences the relative use and price pattern for the various feeds, by regions. Certain feeds, such as peanut meal, are produced in a few concentrated areas of the country, and are consumed largely in these areas. This is in contrast to other feeds, such as meat scraps, which are produced or processed in most States. The broad outlines of the production and processing areas for the various groups of byproduct feeds are indicated in this section. The interrelationship of prices of these feeds, by regions, is illustrated for cottonseed meal and soybean meal in a later section.

OILSEED MEALS

Figure 2 shows the 1954 acreage of the four crops—soybeans, cotton, flax, and peanuts—from which the respective oilseed meals are processed. Acreage of "soybeans for beans" is reported for 30 States by the Crop Reporting Board (*46*); however, the 6 States—Illinois, Indiana, Iowa, Minnesota, Missouri, and Ohio—accounted for 78 percent of the total acreage and 85 percent of total production from the 1954 crop. Acreage of soybeans for beans increased during the 20-year period from 1935 to 1954, from 2.9 million acres to 17 million acres. Data for 1924–56 for soybean acreage, supply and disposition, and production of oil and meal are given in table 24.

Cottonseed production is shown for the 14 principal producing States by the Crop Reporting Board (*46*), together with the aggregate production in 6 other States which account for less than 0.5 percent of the total. In 1954, Arkansas, Louisiana, Mississippi, Missouri, and Tennessee accounted for 33 percent of total cottonseed production; Texas and Oklahoma, for 31 percent; Arizona, California, and New Mexico, for 20 percent; and the southern States of Alabama, Georgia, North Carolina, and South Carolina, for 16 percent. Supply and disposition data for cotton and cottonseed are shown in table 25. Material on yield of products is given in table 26.

Flaxseed acreage and production is centered in Minnesota, North Dakota, and South Dakota; these three States accounted for 93 percent of the United States total in 1954. Production is reported for seven other States, the most important being California, which accounted for 3 percent. Domestic production increased sharply during and following World War II, offsetting a decline in imports, and has continued above the prewar level (see table 27).

Acreage of peanuts picked and threshed is reported for 12 States. The southeastern States of Alabama, Florida, Georgia, Mississippi, and South Carolina accounted for 52 percent of the 1954 acreage, and 43 percent of total production. The States of Virginia and North Carolina accounted for 20 percent of the total acreage, but 42 percent of total production. Yields in Virginia and North Carolina generally are much higher than in other areas. Acreage in Arkansas, New Mexico, Oklahoma, and Texas accounted for 28 percent of the total, and production for 15 percent of the total. Food uses of peanuts accounted for 55 percent of total utilization in 1950–54, and crushings for 34 percent (see table 28).

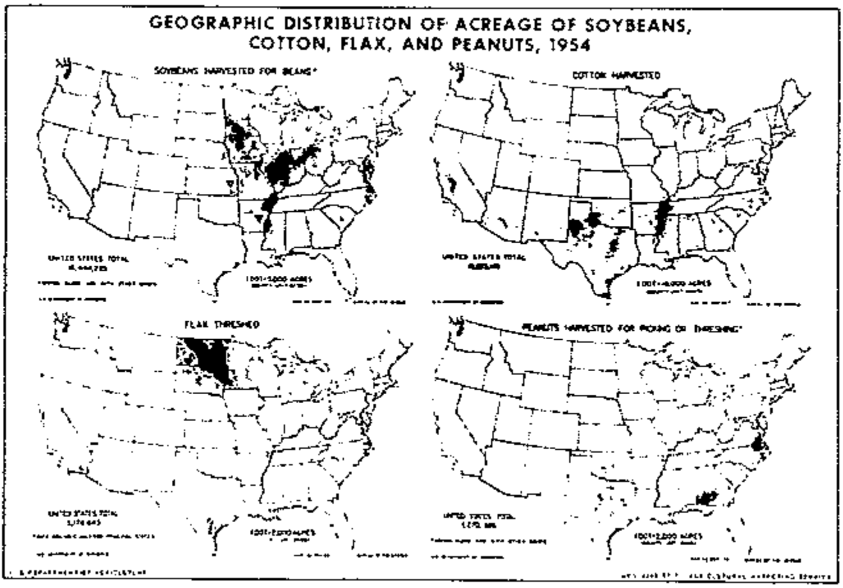

Figure 2. Acreage of the four crops from which domestic production of the oilseed meals is obtained differs as to location. Soybeans are harvested mainly in the North Central region. Cotton acreage is located in the southern States and California. Acreage of flax is centered in Minnesota, North Dakota, and South Dakota. Most of the peanut harvest is in three areas: (1) Virginia and North Carolina; (2) the southeastern region; and (3) Texas and Oklahoma.

Location of oilseed processing plants is given in detail in a report by Kromer and Gilliland (*34*). Special surveys by the Bureau of the Census in cooperation with the Department of Agriculture provide data by States as to the number of mills, quantity processed, and oil yields broken down by method of extraction. Data for the United States are given in table 29 for the 1952–53 season. Yields for meal, by method of extraction, are based on estimates as described in footnotes to that table.

The solvent extraction method was introduced rapidly for soybean processing in the post-World War II period. Data for the 1952–53 season indicate that 86 percent of the soybeans were processed by this method. The solvent method gives a higher oil yield per ton, but a lower meal yield. The meal obtained by the solvent extraction method and the screw press (expeller) method differs in composition, as shown in table 30. A comparison is given also in this table for soybean meal processed from dehulled beans.

TABLE 24.—*Soybeans: Acreage, supply, and disposition, 1924–56* [1]

Year beginning October	Acreage				Supply					Disposition							Production of—			
										Crushings [3]				Exports and shipments	Used for seed	Residual [4]	Oil		Meal	
											For oil and—									
	Total, including interplanted	Grown alone	Harvested for beans	Harvested as a percentage of total	Production	Yield per acre harvested	Imports	Stocks, October 1 [2]	Total supply	Total	Meal	Low-fat flour	For full fat flour				Quantity	Per bushel crushed [5]	Quantity	Per bushel crushed [5]
	1,000 acres	*1,000 acres*	*1,000 acres*	*Pct.*	*Mil. bu.*	*Bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. lb.*	*Lb.*	*1,000 tons*	*Lb.*
1924	1,782	1,567	448	25.1	4.9	11.0	0.1	([6])	5.0	0.3	------	------	------	------	1.9	2.8	2	7.4	8	49.5
1925	1,785	1,539	415	23.2	4.9	11.7	.1	([6])	4.9	.4	------	------	------	------	2.3	2.2	3	7.5	9	49.0
1926	2,127	1,871	466	21.9	5.2	11.2	.1	([6])	5.3	.3	------	------	------	------	2.5	2.5	3	7.9	8	49.6
1927	2,350	2,057	568	24.2	6.9	12.2	.1	([6])	7.0	.6	------	------	------	------	2.7	3.7	4	7.8	14	49.0
1928	2,439	2,15[illegible]	579	23.7	7.9	13.6	.1	([6])	8.0	.9	------	------	------	------	3.0	4.1	7	8.3	22	48.8
1929	2,807	2,429	708	25.2	9.4	13.3	.1	0.1	9.6	1.7	------	------	------	------	3.8	4.1	13	8.1	41	48.9
1930	3,473	3,072	1,074	30.9	13.9	13.0	.1	.1	14.1	4.1	------	------	------	------	4.7	4.8	35	8.5	99	48.5
1931	4,304	3,835	1,141	26.5	17.3	15.1	.1	.5	17.8	4.7	------	------	------	[7] 2.2	4.6	6.2	40	8.5	115	48.6
1932	4,165	3,704	1,001	24.0	15.2	15.1	([6])	.1	15.3	3.5	------	------	------	[7] 2.5	4.5	4.8	29	8.4	84	48.6
1933	3,957	3,537	1,044	26.4	13.5	12.9	([6])	([6])	13.6	3.1	------	------	------	([7] [6])	7.6	2.9	26	8.6	74	48.4
1934	6,207	5,764	1,556	25.1	23.2	14.9	([6])	([6])	23.2	9.1	------	------	------	([7] [6])	10.1	3.7	78	8.6	220	48.4
1935	7,503	6,966	2,915	38.9	48.9	16.8	([6])	.3	49.2	25.2	------	------	------	[7] 3.5	8.9	11.3	209	8.3	613	48.7
1936	7,183	6,127	2,359	32.8	33.7	14.3	([6])	.4	34.1	20.6	------	------	------	([6])	9.5	3.6	184	8.9	496	48.1
1937	7,464	6,332	2,586	34.6	46.2	17.9	([6])	.3	46.5	30.3	------	------	------	1.4	10.9	3.5	270	9.2	724	47.8
1938	8,587	7,318	3,035	35.3	61.9	20.4	([6])	.3	62.2	44.6	------	------	------	4.4	14.7	−2.5	416	9.3	1,064	47.7
1939	10,920	9,565	4,315	39.5	90.1	20.9	([6])	1.0	91.1	56.7	------	------	------	11.0	16.0	7.1	533	9.4	1,349	47.6
1940	11,782	10,487	4,807	40.8	78.0	16.2	([6])	.4	78.4	64.1	------	------	0.1	.3	15.1	−1.8	564	8.8	1,543	48.2
1941	11,345	10,068	5,889	51.9	107.2	18.2	([6])	.7	107.9	77.1	------	------	.5	.5	20.4	3.9	707	9.2	1,845	47.8
1942	14,912	13,696	9,894	66.3	187.5	19.0	([6])	6.0	193.5	133.5	127.0	4.6	1.9	.9	21.0	25.6	1,206	9.0	3,200	48.0
1943	15,428	14,191	10,397	67.4	190.1	18.3	([6])	12.5	202.7	142.3	136.2	4.5	1.6	1.0	19.8	25.5	1,219	8.6	3,446	48.4
1944	14,050	13,118	10,245	72.9	192.1	18.8	([6])	14.2	206.3	153.4	150.6	1.9	.9	5.1	18.9	21.2	1,347	8.8	3,699	48.2
1945	13,807	13,056	10,740	77.8	193.2	18.0	([6])	7.7	200.9	159.5	150.1	8.3	1.1	2.9	16.7	17.5	1,415	8.9	3,837	48.1
1946	12,434	11,706	9,932	79.9	203.4	20.5	([6])	4.4	207.8	170.2	160.6	9.2	.4	[8] 3.8	17.5	10.8	1,531	9.0	4,086	48.0
1947	13,755	13,052	11,411	83.0	186.5	16.3	([6])	5.4	191.8	161.4	144.1	17.1	.2	[8] 2.9	16.1	8.8	1,534	9.5	3,833	47.5
1948	12,617	11,987	10,682	84.7	227.2	21.3	([6])	2.6	229.8	183.7	180.1	3.4	.2	23.0	15.9	4.0	1,807	9.8	4,330	47.2
1949	12,456	11,872	10,482	84.2	234.2	22.3	([6])	3.2	237.4	195.3	191.4	3.7	.2	13.1	18.9	7.2	1,937	9.9	4,586	48.0

1950	15,640	15,048	13,807	88.3	299.2	21.7	(6)	2.9	302.1	252.0	247.0	9 4.8	.2	27.8	19.0	−.9	2,454	9.7	5,897	46.8
1951	15,655	15,176	13,615	87.0	283.7	20.8	(6)	4.2	287.9	244.3	238.8	9 5.3	.3	17.0	19.8	3.2	2,444	10.0	5,704	46.7
1952	16,374	15,958	14,435	88.2	298.8	20.7	(6)	3.6	302.4	234.4	229.0	9 5.1	.2	31.9	20.7	5.3	2,536	10.8	5,551	47.4
1953	16,719	16,394	14,829	88.7	269.2	18.2	0	10.1	279.3	213.2	-------	-------	------	39.7	22.9	2.2	2,350	11.0	5,051	47.4
1954	18,872	18,541	17,047	90.3	341.1	20.0	0	1.3	342.4	249.0	-------	-------	------	60.6	23.4	−.6	2,711	10.9	5,705	45.8
1955	19,959	19,658	18,690	93.6	373.5	20.1	0	9.9	383.5	283.1	-------	-------	------	67.5	26.1	-------	3,143	11.1	6,506	46.0
1956 [10]	21,960	21,671	20,642	94.0	449.4	21.8	0	3.7	453.2	315.9	-------	-------	------	85.4	27.0	-------	3,431	10.9	7,509	47.5

[1] Data available prior to 1942 generally are not as reliable as in subsequent years. Data on domestic production not available prior to 1924.

[2] From 1924 through 1941, stock data are at crushing mills only as reported by the Bureau of the Census. Beginning with 1942, data include stocks on farms, at processing plants, commercial stocks at terminals, CCC stocks in transit to ports, and stocks in interior mills, elevators, and warehouses.

[3] Crushings as reported by Bureau of the Census. Some new-crop soybeans are crushed prior to October 1. These affect the size of the residual item.

[4] Includes soybeans fed to livestock, cleaning and other losses, year-to-year changes in volume of soybeans crushed prior to October 1, and other statistical discrepancies. Substantial amounts were used for feed in 1942–47.

[5] Computed from unrounded data.

[6] Less than 50,000 bushels.

[7] Based on inspections for export by Federal licensed inspectors, first reported in October 1931. Not separately classified by Bureau of the Census prior to January 1, 1937.

[8] Includes exports for civilian feeding abroad by the military forces.

[9] Beginning with 1950, includes crushing for industrial soy flour. Not available 1953 to date.

[10] Preliminary.

TABLE 25.—*Cottonseed: Acreage, yield, supply, and disposition, 1909–56*

Year beginning August	Acreage harvested	Yield per harvested acre	Supply				Disposition			
			Production [1]	Imports [2]	Stocks at mills, August 1	Total	Crushings	Exports [3]	Seed used for planting	Residual [4]
	1,000 acres	*Pounds*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1909	30, 555	290	4, 442	(5)	----------	4, 442	3, 269	13	518	642
1910	31, 508	327	5, 157	1	----------	5, 157	4, 106	6	564	481
1911	34, 916	399	6, 970	1	----------	6, 971	4, 921	32	525	1, 493
1912	32, 557	374	6, 087	2	----------	6, 089	4, 580	12	561	936
1913	35, 206	357	6, 286	4	----------	6, 290	4, 848	8	573	861
1914	35, 615	402	7, 155	11	----------	7, 166	5, 780	3	483	900
1915	29, 951	331	4, 963	15	----------	4, 978	4, 202	1	542	219
1916	33, 071	308	5, 085	27	14	5, 126	4, 479	1	518	96
1917	32, 245	311	5, 012	18	32	5, 062	4, 252	1	570	199
1918	35, 038	305	5, 341	(6)	40	5, 381	4, 479	1	548	329
1919	32, 906	308	5, 069	(6)	24	5, 093	4, 013	2	560	488
1920	34, 408	347	5, 966	(6)	30	5, 996	4, 069	2	466	1, 359
1921	28, 678	246	3, 528	(6)	100	3, 628	3, 008	1	500	106
1922	31, 361	276	4, 330	[7] 28	13	4, 371	3, 242	[8] 1	568	547
1923	35, 550	253	4, 503	44	13	4, 560	3, 308	--------	619	611
1924	39, 501	306	6, 050	36	22	6, 108	4, 605	--------	700	771
1925	44, 386	322	7, 150	44	32	7, 226	5, 558	--------	703	942
1926	44, 608	358	7, 989	16	23	8, 028	6, 306	--------	604	1, 028
1927	38, 342	300	5, 758	(5)	90	5, 848	4, 654	--------	677	495
1928	42, 434	298	6, 319	(5)	22	6, 341	5, 061	--------	684	554
1929	43, 232	296	6, 406	23	42	6, 471	5, 016	--------	670	740
1930	42, 444	284	6, 028	(5)	45	6, 073	4, 715	--------	607	726
1931	38, 704	378	7, 310	1	25	7, 336	5, 328	--------	572	1, 136
1932	35, 891	324	5, 815	3	300	6, 118	4, 621	--------	622	654
1933	29, 383	375	5, 511	1	221	5, 733	4, 157	--------	432	921
1934	26, 866	317	4, 256	51	223	4, 530	3, 550	--------	435	455
1935	27, 509	337	4, 634	(5)	90	4, 724	3, 818	--------	475	409

1936	29, 755	368	5, 472	--------	22	5, 494	4, 498	--------	534	420
1937	33, 623	467	7, 844	--------	42	7, 886	6, 326	--------	394	829
1938	24, 248	408	4, 950	--------	337	5, 287	4, 471	--------	389	306
1939	23, 805	409	4, 869	--------	121	4, 990	4, 151	--------	394	405
1940	23, 861	443	5, 286	--------	40	5, 326	4, 398	--------	367	430
1941	22, 236	410	4, 553	--------	131	4, 684	4, 008	--------	367	227
1942	22, 602	460	5, 202	--------	82	5, 284	4, 498	3	344	349
1943	21, 610	434	4, 688	--------	90	4, 778	3, 955	3	317	385
1944	19, 617	500	4, 902	(5)	118	5, 020	4, 254	4	279	264
1945	17, 029	430	3, 664	--------	219	3, 883	3, 262	4	286	213
1946	17, 584	400	3, 514	--------	118	3, 632	3, 090	8	320	114
1947	21, 330	439	4, 682	--------	100	4, 782	4, 082	5	315	291
1948	22, 911	519	5, 945	--------	89	6, 034	5, 332	6	384	180
1949	27, 439	478	6, 559	--------	132	6, 691	5, 712	11	279	401
1950	17, 843	460	4, 105	1	288	4, 394	3, 723	6	419	180
1951	26, 949	467	6, 286	--------	66	6, 352	5, 476	11	414	313
1952	25, 921	478	6, 190	--------	137	6, 327	5, 563	13	406	190
1953	24, 341	554	6, 748	--------	155	6, 903	6, 256	15	346	57
1954	19, 251	593	5, 709	--------	229	5, 938	5, 249	21	263	196
1955	16, 928	714	6, 043	--------	209	6, 252	5, 588	16	266	205
1956 [9]	15, 615	695	5, 407	--------	177	5, 584	4, 949	11	225	235

[1] Before 1928, production of cottonseed was computed on the basis of 65 pounds of seed to 35 pounds of lint.
[2] Year beginning July. Imports for consumption, 1909–17 and 1933 date; general imports, 1922–32.
[3] Not reported separately, 1923–41.
[4] Mainly used on farms for feed and fertilizer.
[5] Less than 500 tons.
[6] Available on calendar year basis only.
[7] September 2, 1922–June 30, 1923.
[8] August–December 1922.
[9] Preliminary.

TABLE 26.—*Cottonseed: Crushings and products produced, 1909–56*

Year beginning August	Crushings	Production					Yield per ton crushed				
		Oil	Meal	Linters [1]	Hulls	Other, including loss [2]	Oil	Meal	Linters [1]	Hulls	Other, including loss [2]
	1,000 tons	*Million pounds*	*Million pounds*	*Million pounds*	*Million pounds*	*Million pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1909	3, 269	982	2, 652	148	2, 578	178	301	811	45	789	54
1910	4, 106	1, 260	3, 584	190	2, 750	428	307	873	46	670	104
1911	4, 921	1, 512	4, 302	267	3, 284	477	307	874	54	667	98
1912	4, 580	1, 393	3, 998	292	3, 080	397	304	873	64	672	87
1913	4, 848	1, 450	4, 440	306	2, 800	700	299	916	63	578	144
1914	5, 780	1, 719	5, 296	410	3, 354	781	297	916	71	580	136
1915	4, 202	1, 253	3, 846	445	2, 440	420	298	915	106	581	100
1916	4, 479	1, 408	4, 450	637	1, 938	525	314	993	142	433	118
1917	4, 252	1, 312	4, 146	539	1, 992	525	309	972	127	467	125
1918	4, 479	1, 325	4, 340	445	2, 274	574	296	969	99	508	128
1919	4, 013	1, 211	3, 634	291	2, 286	604	302	906	72	570	150
1920	4, 069	1, 309	3, 572	211	2, 512	534	322	878	52	619	129
1921	3, 008	930	2, 709	190	1, 874	313	309	901	63	623	104
1922	3, 242	1, 003	2, 974	291	1, 888	328	309	918	90	582	101
1923	3, 308	980	3, 036	320	1, 882	398	296	918	97	569	120
1924	4, 605	1, 404	4, 251	430	2, 662	463	305	923	93	578	101
1925	5, 558	1, 617	5, 193	534	3, 095	677	291	934	96	557	122
1926	6, 306	1, 888	5, 680	556	3, 709	779	299	901	88	588	124
1927	4, 654	1, 477	4, 187	489	2, 640	515	317	900	105	567	111
1928	5, 061	1, 604	4, 563	617	2, 737	601	317	902	122	541	118
1929	5, 016	1, 572	4, 464	598	2, 767	631	313	890	119	552	126
1930	4, 715	1, 442	4, 330	475	2, 607	576	306	918	101	553	122
1931	5, 328	1, 694	4, 802	514	3, 022	624	318	901	97	567	117
1932	4, 621	1, 446	4, 186	440	2, 625	545	313	906	95	568	118
1933	4, 157	1, 303	3, 777	474	2, 207	553	313	909	114	531	133
1934	3, 550	1, 109	3, 229	483	1, 826	453	312	910	136	514	128
1935	3, 818	1, 164	3, 478	525	1, 976	493	305	911	138	518	128
1936	4, 498	1, 364	4, 063	679	2, 288	602	303	903	151	509	134

1937	6, 326	1, 961	5, 661	877	3, 252	901	310	895	139	514	142
1938	4, 471	1, 409	4, 047	665	2, 322	499	315	905	149	519	112
1939	4, 151	1, 325	3, 764	642	2, 110	461	319	907	155	508	111
1940	4, 398	1, 425	3, 907	727	2, 214	523	324	888	165	504	119
1941	4, 008	1, 250	3, 505	718	1, 983	560	312	874	179	495	140
1942	4, 498	1, 401	3, 989	822	2, 170	614	311	887	183	482	137
1943	3, 955	1, 236	3, 669	703	1, 853	449	313	928	178	469	112
1944	4, 254	1, 324	3, 908	748	1, 968	560	311	919	176	463	131
1945	3, 262	1, 018	2, 869	593	1, 567	477	312	879	182	480	147
1946	3, 090	973	2, 725	589	1, 454	439	315	882	191	471	141
1947	4, 082	1, 276	3, 797	758	1, 847	486	313	930	186	452	119
1948	5, 332	1, 704	4, 782	977	2, 471	729	320	897	183	463	137
1949	5, 712	1, 847	5, 111	1, 007	2, 675	784	323	895	176	469	137
1950	3, 723	1, 197	3, 338	687	1, 714	510	321	896	185	461	137
1951	5, 476	1, 751	5, 096	1, 013	2, 469	612	320	930	185	451	114
1052	5, 563	1, 825	5, 345	1, 026	2, 398	516	328	961	184	431	95
1953	6, 256	2, 094	5, 921	1, 150	2, 775	576	332	946	184	444	94
1954	5, 249	1, 735	5, 122	986	2, 278	376	331	976	188	434	72
1955	5, 588	1, 894	5, 261	990	2, 498	532	339	942	177	447	92
1956 [3]	4, 949	1, 682	4, 772	877	2, 142	424	340	964	180	433	83

[1] Computed from production reported in terms of equivalent 500-pound bales on the basis of net weight.
[2] Includes motes, grabbots, and hullfibers.
[3] Preliminary.

TABLE 27.—*Flaxseed: Acreage, supply, and disposition, 1920–56* [1]

Year beginning July	Acreage harvested	Yield per harvested acre	Supply				Disposition				Production of—			
											Oil		Meal	
			Production	Imports	Stocks, July 1 [2]	Total supply	Crushing	Exports	Used for seed [3]	Residual [4]	Quantity	Per bushel crushed	Quantity	Per bushel crushed
	1,000 acres	*Bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million pounds*	*Pounds*	*1,000 tons*	*Pounds*
1920	1, 647	6. 6	10. 9	16. 2	0. 5	27. 5	25. 6	(5)	0. 6	−4. 3	484	18. 9	459	35. 9
1921	1, 143	7. 1	8. 1	13. 6	5. 7	27. 4	23. 5	(5)	. 6	1. 9	440	18. 7	425	36. 2
1922	1, 113	9. 5	10. 5	25. 0	1. 4	36. 9	31. 1	-------	1. 1	1. 3	595	19. 1	555	35. 7
1923	2, 015	8. 2	16. 6	19. 6	3. 5	39. 6	36. 2	-------	1. 9	−. 3	674	18. 6	656	36. 2
1924	3, 535	8. 8	31. 2	13. 4	1. 9	46. 5	40. 7	-------	1. 6	. 2	751	18. 5	742	36. 5
1925	3, 022	7. 4	22. 3	19. 4	4. 0	45. 7	38. 0	-------	1. 6	1. 4	704	18. 5	692	36. 4
1926	2, 736	6. 8	18. 5	24. 2	4. 7	47. 5	40. 6	-------	1. 5	−. 2	750	18. 5	738	36. 4
1927	2, 763	9. 1	25. 2	18. 1	5. 6	48. 9	43. 2	-------	1. 4	. 1	811	18. 8	781	36. 2
1928	2, 611	7. 3	19. 1	23. 5	4. 2	46. 8	39. 6	-------	1. 7	. 5	738	18. 6	718	36. 3
1929	3, 049	5. 2	15. 9	19. 7	5. 0	40. 6	35. 5	-------	2. 3	−. 4	651	18. 3	649	36. 5
1930	3, 780	5. 7	21. 7	7. 8	3. 2	32. 7	27. 1	-------	2. 0	1. 1	489	18. 0	498	36. 8
1931	2, 431	4. 8	11. 8	13. 8	2. 5	28. 1	23. 7	-------	1. 4	. 1	439	18. 5	431	36. 4
1932	1, 988	5. 8	11. 5	6. 2	2. 9	20. 6	17. 4	-------	1. 0	. 1	318	18. 3	318	36. 6
1933	1, 341	5. 1	6. 9	17. 9	2. 1	26. 9	23. 0	-------	. 9	. 5	443	19. 3	410	35. 6
1934	1, 002	5. 7	5. 7	15. 3	2. 5	23. 6	20. 7	-------	1. 3	−. 7	404	19. 5	367	35. 4
1935	2, 126	7. 0	14. 9	15. 4	2. 2	32. 5	26. 5	-------	1. 4	1. 3	506	19. 1	476	35. 8
1936	1, 125	4. 7	5. 3	26. 1	3. 3	34. 8	30. 3	-------	. 7	. 5	587	19. 4	539	35. 5
1937	927	7. 6	7. 1	17. 9	3. 3	28. 3	25. 9	-------	. 6	−. 4	505	19. 5	458	35. 4
1938	905	8. 9	8. 0	18. 7	2. 2	29. 0	25. 6	-------	1. 4	−. 3	502	19. 6	451	35. 3
1939	2, 171	9. 0	19. 6	13. 2	2. 3	35. 1	30. 1	-------	2. 0	−. 9	579	19. 2	536	35. 6
1940	3, 182	9. 7	30. 9	11. 2	3. 9	46. 0	36. 6	-------	2. 3	−. 3	707	19. 3	652	35. 6
1941	3, 266	9. 8	32. 1	23. 3	7. 4	62. 8	51. 2	(5)	3. 0	2. 4	988	19. 3	911	35. 6
1942	4, 408	9. 3	41. 0	6. 3	6. 2	53. 5	44. 3	(5)	3. 8	1. 0	849	19. 2	790	35. 7

1943	5,691	8.8	50.0	16.8	4.4	71.2	54.6	([5])	1.8	2.6	1,047	19.2	975	35.7
1944	2,610	8.3	21.7	5.1	12.2	38.9	32.9	([5])	2.4	.5	633	19.2	585	35.6
1945	3,785	9.1	34.6	3.4	3.1	41.1	29.4	([5])	1.7	3.4	589	20.0	511	34.8
1946	2,432	9.3	22.6	1.4	6.6	30.6	24.6	([5])	2.6	1.7	485	19.7	432	35.2
1947	4,129	9.8	40.6	.7	1.7	43.0	30.1	([5])	3.2	2.5	595	19.8	528	35.1
1948	4,973	11.0	54.8	.6	7.2	62.6	37.3	4.7	3.5	−1.0	737	19.8	670	35.9
1949	5,048	8.5	43.0	([5])	19.4	62.3	37.4	2.0	2.8	2.0	728	19.5	694	37.1
1950	4,090	9.8	40.2	([5])	17.0	57.2	42.3	2.9	2.7	−3.0	844	20.0	770	36.4
1951	3,904	8.9	34.7	([5])	12.3	47.0	30.3	4.2	2.3	−1.3	609	20.1	547	36.2
1952	3,303	9.1	30.2	([5])	11.5	41.7	25.2	.2	3.2	3.1	507	20.1	460	36.5
1953	4,570	8.2	37.7	([5])	10.0	47.6	27.8	2.4	3.9	−.7	551	19.8	500	36.0
1954	5,663	7.3	41.3	([5])	14.2	55.5	32.3	8.2	3.5	.3	632	19.6	592	36.7
1955	4,981	8.3	41.2	([5])	11.2	52.4	34.9	10.4	3.9	−1.0	695	19.9	643	36.8
1956 [6]	5,545	8.8	48.0	([5])	4.1	52.8	26.1	3.0	3.9	.3	531	20.3	482	36.9

[1] Data for 1920 generally are not as reliable as in subsequent years. Data computed from unrounded figures.

[2] 1920, stocks held in public storage houses in Minneapolis and Duluth on Saturday nearest July 1, as published in *1925 Agricultural Yearbook (66)*; 1921–47, off-farm stocks include those at crushing plants and terminal elevators only; 1948 to date, stocks at terminals, processing plants, interior mills and elevators, and warehouses are included. Stocks on farms 1921–47 were estimated unofficially based on movement of the crop to principal markets; 1948 to date, based on reports of the Crop Reporting Board.

[3] In the following year.

[4] Includes shrinkage and cleaning losses, change in stocks in unreported positions, and statistical discrepancies reflecting in part the inclusion of some new crop seed in stocks and crushings.

[5] Less than 50,000 bushels.

[6] **Preliminary.**

TABLE 28.—*Peanuts: Acreage, yield, supply, and disposition, 1916–56*

Year beginning [1]	Acreage picked and threshed	Supply							Disposition, kernel basis							Production		
		Production picked and threshed											Crushings			Oil		
		Per acre	Farmers' stock basis	Conversion factor [2]	Kernel basis	Imports [3]	Beginning stocks [4]	Total, kernel basis	Exports and shipments	Used for seed	Residual [5]	Food uses	Farmers' stock [6]	Shelled [6]	Total	Quantity	Yield per 100 pounds crushed	Meal
	1,000 acres	*Pounds*	*Million pounds*	*Percent*	*Million pounds*	*Million pounds*	*Million pounds*	*Million pounds*	*Million pounds*	*Million pounds*	*Million pounds*	*Million pounds*	*Million pounds*	*Million pounds*	*Million pounds*	*Million pounds*	*Pounds*	*1,000 tons*
1916	878	758	666	(7)	444	42	------	486	19	53	10	286	(118)	------	(118)	40	34.2	39
1917	1,314	752	989	(7)	659	67	------	726	12	55	10	434	(215)	------	(215)	73	34.2	71
1918	1,326	713	946	(7)	631	28	------	659	13	47	11	294	(294)	------	(294)	101	34.2	96
1919	957	719	688	(7)	459	125	------	584	11	50	11	484	7	17	23	8	35.8	8
1920	995	699	696	(7)	464	39	5	508	12	50	46	321	50	24	75	28	37.9	23
1921	980	692	678	(7)	452	10	4	466	12	44	38	293	56	21	77	30	39.7	23
1922	821	637	523	(7)	349	35	2	386	6	43	13	303	9	12	21	7	34.2	7
1923	797	713	568	(7)	379	49	(8)	428	3	54	−8	365	1	11	12	4	35.3	4
1924	1,084	658	713	(7)	475	70	2	547	3	51	25	403	7	39	46	15	33.2	15
1925	996	725	722	(7)	481	38	19	538	4	47	5	418	5	28	33	12	35.7	11
1926	860	770	662	(7)	441	41	31	513	4	57	14	398	1	22	23	8	34.2	8
1927	1,086	777	844	(7)	563	42	17	622	5	61	−8	473	13	28	41	14	34.6	13
1928	1,213	695	844	(7)	563	35	50	648	5	63	14	455	5	33	37	13	34.7	12
1929	1,262	712	898	(7)	599	10	74	683	3	57	−4	499	19	61	81	27	33.6	27
1930	1,073	650	697	(7)	465	4	47	516	2	69	6	392	8	38	46	16	33.5	15
1931	1,440	733	1,056	(7)	704	1	1	706	5	78	29	553	6	29	34	12	33.7	11
1932	1,501	627	941	(7)	627	(8)	7	634	3	68	−2	518	6	38	44	15	33.2	15
1933	1,217	673	820	(7)	547	(8)	3	550	1	77	−17	455	2	28	30	10	32.6	10
1934	1,514	670	1,014	(7)	676	(8)	4	680	(8)	80	12	424	106	54	160	56	34.8	44
1935	1,497	770	1,153	(7)	769	(8)	4	773	(8)	86	29	514	104	39	143	64	45.1	46
1936	1,660	759	1,260	(7)	840	2	1	843	(8)	80	4	590	110	56	166	78	46.8	57
1937	1,538	802	1,233	(7)	822	3	3	828	1	88	18	566	114	38	152	67	44.1	48
1938	1,692	762	1,289	65.75	848	6	97	951	1	95	33	567	171	26	197	85	43.1	65
1939	1,908	636	1,213	68.12	826	6	58	890	1	99	9	578	49	32	81	32	40.0	30
1940	2,052	861	1,767	67.71	1,196	3	122	1,321	1	102	24	657	378	30	407	174	42.7	134
1941	1,900	776	1,475	67.76	1,000	1	130	1,131	6	180	14	677	149	27	176	77	43.4	57
1942	3,355	654	2,193	68.69	1,506	3	78	1,587	3	198	27	903	268	40	308	131	42.4	100
1943	3,528	617	2,176	67.22	1,463	1	148	1,612	24	160	58	884	274	47	321	135	42.1	108
1944	3,068	678	2,081	69.41	1,444	59	165	1,668	20	165	26	991	83	217	299	120	39.9	100
1945	3,160	646	2,042	70.18	1,433	(8)	167	1,600	44	159	53	882	63	202	265	107	40.2	88
1946	3,141	649	2,038	68.72	1,401	(8)	197	1,598	173	164	44	712	181	186	367	149	40.6	123
1947	3,377	646	2,182	69.91	1,525	(8)	138	1,663	338	156	46	667	200	134	334	139	41.6	121
1948	3,296	709	2,336	69.99	1,635	(8)	122	1,757	533	116	42	644	112	226	338	144	42.5	116
1949	2,308	808	1,865	71.06	1,325	(8)	84	1,409	93	119	42	639	20	415	435	184	42.4	139
1950	2,262	900	2,037	70.40	1,434	(8)	84	1,517	51	113	30	677	37	415	452	189	42.0	151

1951	1,982	837	1,676	69.65	1,167	--------	178	1,333	3	81	26	607	145	144	289	125	43.3	96
1952	1,443	940	1,356	68.83	933	--------	231	1,164	2	73	21	701	0	136	136	53	26.7	42
1953	1,515	1,039	1,574	68.84	1,084	--------	235	1,319	156	76	14	719	0	210	210	84	27.5	64
1954	1,387	727	1,008	67.18	677	122	149	948	6	83	−1	669	0	63	63	22	23.5	21
1955	1,669	928	1,548	71.05	1,100	4	134	1,258	6	78	18	700	0	189	189	76	29.1	56
1956 [9]	1,385	1,157	1,607	71.43	1,113	3	257	1,373	3	77	10	793	0	192	192	76	29.4	57

[1] Year beginning August in the southwestern section, September in the southeastern section, and November in the Virginia-Carolina section.
[2] Percentage yield of kernels (both edible and oil stock) from shelling of farmers' stock peanuts.
[3] 1916–21, general imports; 1922–date, imports for consumption.
[4] Includes stocks at crushing mills on Oct. 1, 1919–37, at cold storage warehouses in the North and Middle West on July 1, September 1, or Oct. 1, 1925–30, and in all commercial positions on Sept. 1, 1938, to date.
[5] Includes use for feed, losses on farms, shrinkage at mills, change in stocks in unreported positions, adjustments for new-crop peanuts included in beginning stocks, and statistical discrepancies.
[6] 1916–18, estimated from production of peanut oil; 1919–37, reported by Bureau of the Census, year beginning Oct. 1; 1938 to date, reported by Agricultural Marketing Service, year beginning September 1.
[7] Yield in years prior to 1938 estimated at 66.67 percent.
[8] Less than 500,000 pounds.
[9] Preliminary.

TABLE 29.—*Principal oilseeds: Percentage processed and yield of oil and meal per ton by method of processing United States, marketing year beginning 1952* [1]

Item	Soybeans	Cottonseed	Linseed	Peanuts
Percentage of total processed:	*Percent*	*Percent*	*Percent*	*Percent*
Hydraulic press	1	46		
Screw press	13	33	54	
Solvent extraction	[2] 86	21	(3)	
Total	100	100	100	100
Yield per ton:				
Oil:	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Hydraulic press	270	310		
Screw press	304	327	714	
Solvent extraction	370	370		
All	360	328	[4] 718	[5] 780
Meal: [6]				
Hydraulic press	1,707	979		
Screw press	1,603	962		
Solvent extraction	1,607	919		
All	1,617	961	[4] 1,289	[5] 1,220

[1] Data on yield of oil per ton by method of processing for soybeans, cottonseed, and linseed based on special survey by the Bureau of Census and the United States Department of Agriculture. Yield of meal per ton indicated for total processed only. Data for soybeans refer to the October–September year; cottonseed, August–July year; linseed, July–June year; and peanuts, September–August year.

[2] Adoption of the solvent method of processing was rapid in the post-World War II period, as indicated by the following average percentages of total processed in the indicated years beginning October: 1936–40, 19 percent; 1941–45, 21 percent, 1946–49, 41 percent. Data for individual years, by method of extraction, are summarized in Kromer and Gilliland (*34*, p. 6) and in a more recent report by Kromer (*33*).

[3] The remaining 46 percent is largely prepress solvent. In 1951–52, the screw press method accounted for 53 percent of the total processed; prepress solvent, 30 percent, and other methods, 17 percent.

[4] Total yield of oil and meal add to more than one ton since some oil is recovered from the processing of screenings.

[5] Yield on a kernel basis.

[6] Estimated by assuming that the processing loss, or production of other products in the case of cottonseed, equals that for the total quantity processed.

Processing of cottonseed is done mainly by the hydraulic and screw press methods, as shown in table 29. The yield of oil is highest for the solvent extraction method, followed by the screw press and the hydraulic methods. The recovery of oil per ton processed averages less for cottonseed than for soybeans, as a larger percentage of soybeans are processed by the higher-yielding solvent extraction method. The yield of meal per ton from cottonseed processing is considerably less than for soybeans, as linters and hulls also are obtained as byproducts. For the 1952–53 season, the yield of the various products per ton processed were as follows: Oil, 328 pounds; meal, 961 pounds;

linters, 184 pounds; and hulls, 431 pounds. Cottonseed meal is sold generally with a guaranteed protein content of 41 percent. Meal produced from the solvent extraction method averages lower in fat content and productive energy than that produced by the hydraulic or screw press methods. Relative importance of cottonseed processing areas corresponds closely to the pattern of production in the several areas.

TABLE 30.—*Soybean meal: Composition, by method of extraction*

Nutritive element	Method of extraction		
	Expeller	Solvent when beans are—	
		Not dehulled	Dehulled
	Percent	*Percent*	*Percent*
Fat	3.5	0.5	0.5
Fiber	6.0	6.5	3.0
Protein	42	45	50
	Calories	*Calories*	*Calories*
Productive energy per pound	640	570	650

Hubbell (22, p. 14).

Linseed processing is centered in Minnesota—that State accounted for 72 percent of the total quantity processed in the 1951–52 season. New York, Pennsylvania, Ohio, and Illinois processed 20 percent; California, 6 percent; and other States, 2 percent. As shown in table 29, the screw press method accounted for 54 percent of all linseed processed. Data on other methods were not indicated for the 1952–53 season; for the 1951–52 season, the screw press method accounted for 53 percent; prepress solvent, 30 percent; and other methods, 17 percent. The oil content and the recovery of oil is high for linseed—about twice that of soybeans—so that the meal obtained per ton processed is correspondingly less. Solvent-process linseed meal contains 34 percent protein as compared with 32 percent for screw-press meal, but it has a lower fat content and productive energy. Protein content of linseed meal varies somewhat from year to year.

Peanut processing is done mainly by the hydraulic and screw press methods. Data on processing by States are not readily available, but it is known to correspond in general with the producing areas. The oil yield from peanuts (on a kernel basis), as shown in table 29, is higher than for the other oilseeds. The meal yield is lower than for soybeans and linseed but higher than for cottonseed.

The value of individual products obtained from processing soybeans, cottonseed, linseed, and peanuts, expressed as a percentage of the total value, are given in table 31 for the seasons 1947 to date. These data are published regularly by the Agricultural Marketing Service (*49*) and are calculated from values obtained by multiplying the yield of

TABLE 31.—*Principal oilseeds: Value of products expressed as a percentage of total value, 1947–56* [1]

Year beginning	Soybeans [2]		Cottonseed [3]			Linseed [4]		Peanuts [5]	
	Oil	Meal	Oil	Meal	Other	Oil	Meal	Oil	Meal
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1947	54	46	60	28	12	80	20	79	21
1948	45	55	59	31	10	81	19	76	24
1949	44	56	51	34	15	73	27	74	26
1950	53	47	50	24	26	76	24	80	20
1951	36	64	43	37	20	72	28	70	30
1952	44	56	49	36	15	68	32	77	23
1953	44	56	53	34	13	70	30	75	25
1954	48	52	52	36	12	68	32	72	28
1955	54	46	57	33	10	73	27	80	20
1956 [6]	55	45	55	32	13	73	27	81	19

[1] Values calculated by multiplying yield by simple average price, using specified quotations noted below.

[2] October–September season. Price quotations are: Soybean oil, crude, tank cars, f. o. b. Midwest mills; soybean meal, bulk, Decatur, quoted as 41 percent prior to July 1950 and 44 percent protein content beginning July 1950.

[3] August–July season. Price quotations are: Cottonseed oil, crude, f. o. b. southeastern mills; cottonseed meal, 41 percent protein content, bulk, carlots, Memphis. Other products include linters and hulls.

[4] July–June season. Price quotations are: Linseed oil, raw in tank cars, Minneapolis; linseed meal, bagged, carlots at Minneapolis. Protein content, 34 percent prior to July 1950 and 36 percent since that date.

[5] September–August season. Price quotations are: Peanut oil, crude, tank cars, f. o. b. southeastern mills; peanut meal, 45 percent protein content, f. o. b. southeastern mills.

[6] Preliminary.

the several products by simple average prices using specified quotations. The value of soybean meal exceeded the value of the oil in 6 of the 9 seasons during 1947–55. A similar longer-term series, calculated by using the price of soybean meal, bagged, at Chicago rather than the bulk price at Decatur, indicates a value of meal higher than that for oil in 13 of the 16 seasons during 1931–46. The relative value of the meal in soybean processing is more important than for cottonseed, linseed, and peanut processing.

ANIMAL BYPRODUCT FEEDS

Production of meat scraps in 1957 was more evenly distributed throughout the country than was production of tankage for feed (see table 32). Meat scrap production during 1957 amounted to 1,159,000 tons, or four times the quantity of tankage produced for feed.

Milk products fed to livestock in the year beginning October 1954 is estimated at 1,330,000 tons, dry-weight equivalent. Commercial milk products fed to livestock, including skim milk (dried and concentrated), buttermilk (dried and concentrated), and whey (concentrated, condensed and dried), amounted to about 170,000 tons for this

TABLE 32.—*Meat scraps and tankage: Production by regions, 1957*

Region	Meat scraps (or meat meal)		Tankage [1] (digester or feeding)	
	Amount	Percentage of total	Amount	Percentage of total
	1,000 tons	*Percent*	*1,000 tons*	*Percent*
North Atlantic	253.8	22	23.9	8
East North Central	321.0	28	76.4	27
West North Central	176.2	15	124.2	44
South Atlantic	89.2	8	27.8	10
South Central	135.6	12	23.9	8
Mountain	26.7	2	6.5	2
Pacific	156.5	13	1.4	1
Total	1,159.0	100	284.1	100

[1] Excludes tankage produced for fertilizer.
Special tabulation prepared by the Crop Reporting Board, Agricultural Marketing Service.

year, including 27,000 tons of sales by the Commodity Credit Corporation for feed use. A large proportion of these products are produced in surplus milk producing areas of the Midwest. Noncommercial milk products fed on farms where produced are estimated at 1,160,000 tons (dry-weight basis) for the year beginning October 1954; these include skim milk, buttermilk, whole milk, and whey. Regional use of these products is related chiefly to the areas of production of butter, cream, and cheese.

FISH BYPRODUCT FEEDS

Fish meal production by area and species is reported annually in Canned Fish and Byproducts (*67*). Production on the Atlantic and Gulf Coasts accounted for 85 percent of domestic production in 1955. Menhaden meal is by far the most important, accounting for about 70 percent of total United States production. Crab, groundfish, and Maine herring are other important meals produced in this area. Production on the Pacific Coast, Alaska, and American Samoa currently accounts for about 15 percent of the United States total. Tuna and mackeral meal is most important, followed by sardine and Alaska herring meals.

The quarterly pattern of production for important meals for 1955 is shown in table 33. This pattern is similar for the last few years, although yearly differences are important. Maine herring meal is produced mainly in the second and third quarters of the year. This also holds true for menhaden meal, with no production reported for February and March, and negligible quantities in January, for the five years 1951–55. On the West Coast, Alaska herring meal is produced in June, July and August, with minor quantities reported for some years in September. Production of tuna and mackerel meal is less seasonal. Imports of meal even out some of the seasonal pattern. In each year during 1951–55, imports were larger than production in the first quarter of the year, and for the month of December in three of the five years.

Production trends by species are shown in table 34. Menhaden meal has shown the sharpest increase in production since 1931–35. Production of acidulated menhaden scrap and meal, which is not used for feed purposes and is excluded from the data in table 34, amounted to 15,000 tons annually in 1931–35, but currently is negligible. Production of sardine meal on the Pacific Coast has declined drastically in recent years. In 1931–35, this meal accounted for 42 percent of the total production in the United States, whereas in 1950–54, it amounted to less than 3 percent. Production of tuna and mackerel meal has increased, as has production of "other" meal. A large proportion of "other" meal is produced on the Atlantic and Gulf Coasts; crab meal and groundfish meal are the principal classified items.

TABLE 33.—*Fish meal: Production by kind, imports, and supply, 1955, and percentage distribution by quarters*

Item	1955	Percentage distribution by quarters			
		I	II	III	IV
	1,000 tons	*Percent*	*Percent*	*Percent*	*Percent*
Production:[1]					
Atlantic and Gulf Coasts:					
Maine herring	3.2	1	38	45	16
Menhaden[2]	190.6		29	55	16
Other[3]	29.9				
Total	223.7				
Pacific Coast, Alaska, and Samoa:					
Alaskan herring	4.5		27	73	
Sardine (Pilchard)	7.0	1			99
Tuna and mackerel	23.4	20	29	27	24
Other	5.7				
Total	40.6				
Total production[4]	264.3	3	29	50	18
Imports	88.5	29	28	17	26
Supply	352.8	10	29	41	20

[1] From *Canned Fish and Byproducts—1955 (67)* and *Fish Meal and Oil (68)*.

[2] Production by specified groups of States is as follows, expressed in thousand tons: Maine, Massachusetts, Rhode Island, 6.0; New York, New Jersey, Delaware, Maryland, 79.2; Virginia, 32.7; North Carolina, South Carolina, 19.9; Mississippi, 12.6; Florida, Texas, 9.0; and Louisiana, 31.2.

[3] Includes some unclassified meal produced in Minnesota.

[4] "Other" meal amounting to 16.7 thousand tons allocated by quarters using factors provided by the Fish and Wildlife Service.

On the Pacific Coast, salmon, crab, anchovy, and fur seal meals are included in the "other" category, as shown in table 34, in addition to unclassified meals.

TABLE 34.—*Fish meal: Production by kind, averages 1931–55* [1]

Period	Menhaden [2]	Herring	Sardine (Pilchard)	Tuna and mackerel	Other	Total
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
Average:						
1931–35	31.5	12.6	55.5	[3] 8.6	23.4	131.6
1936–40	45.3	16.5	93.6	12.6	27.9	195.9
1941–45	67.7	11.2	78.5	8.7	32.4	198.5
1946–50	102.8	15.7	31.0	19.8	42.6	211.9
1951–55	161.6	7.9	6.2	22.0	40.5	238.2

[1] From *Canned Fish and Byproducts—1955* (*67*).
[2] Excludes acidulated menhaden scrap which amounted to an average of 15.4 thousand tons in 1931–35; 21.7 thousand tons in 1936–40; 3.9 thousand tons in 1941–45; 1.3 thousand tons in 1946–47. Small quantities produced from 1948–52 are included in these data but since that time production has been negligible.
[3] 1932–35 average.

Production of fish solubles, reported since 1944, has increased from 12,600 tons (6,300 tons on a 50 percent solids basis) to 78,500 tons (39,300 tons on a 50 percent solids basis) in 1955. The location of this production for 1955 is as follows:

	1,000 tons
Maine, Massachusetts	7.1
New York, New Jersey, Delaware	31.0
Virginia	1.6
North Carolina, Florida	3.4
Mississippi	5.1
Louisiana, Texas	7.7
California, Oregon	22.6
Total	78.5

In addition to the fish solubles production, another product—homogenized-condensed fish—is produced in Massachusetts and Rhode Island. Production for 1955 is reported (*68*) at 20,600 tons.

GRAIN HIGH-PROTEIN FEEDS

Gluten feed and meal and corn oil meal are produced in a limited number of plants—mainly in the Central States—that are engaged in the wet-processing of corn. Data on sales of these products are reported for the total industry but are not available by States.

Brewers' dried grains production is reported to the Agricultural Marketing Service by companies having plants in 15 States. In 1954, production in the four States of Illinois, Missouri, New York, and Wisconsin accounted for 68 percent of the total United States production, with an approximately equal distribution between these States for that year.

Distillers' dried grains and solubles production is reported to the Agricultural Marketing Service by companies having plants in eight States. In 1954, production in Kentucky accounted for 44 percent of the United States total, and in Indiana for 25 percent.

OTHER BYPRODUCT FEEDS

Wheat millfeed production, by States, is reported annually by the Bureau of the Census (*62*). Wheat grindings and offal production are indicated for 18 States, with the production of wheat millfeeds in "other States" in 1955 accounting for 10 percent of the United States total. For that year, the five leading States were Kansas (13 percent), New York (12 percent), Minnesota (12 percent), Missouri (9 percent) and Illinois (7 percent).

Dehydrated and suncured alfalfa meal production are reported separately by months by the Agricultural Marketing Service (*52*). Production, also is reported by States for the April–March season. For April–March 1955–56, production of dehydrated alfalfa meal amounted to 1,173,000 tons, or 86 percent of the total. Nebraska produced 33 percent of the total, followed in importance by Kansas (15 percent), Colorado (9 percent), California (9 percent), Ohio (8 percent), and Missouri (6 percent). For suncured alfalfa meal, California produced 55 percent of the total production of 190,000 tons in this season, followed in importance by Colorado (11 percent), Idaho (8 percent), Nebraska (7 percent), and Ohio (7 percent).

Beet pulp production is not reported by States, but its distribution probably corresponds approximately to the production of sugar beets, which are reported separately for 16 States and in the aggregate for other States by the Crop Reporting Board (*46*). Production of sugar beets in the Western States for 1954 amounted to 76 percent of the total. California is the leading State, followed by Colorado and Idaho. Production in the Central States accounted for 24 percent of the total.

Rice millfeed production is obtained monthly for the total United States by the Agricultural Marketing Service. Unpublished data for 1955 indicate about 20 percent of the total produced in California and the remaining 80 percent in the southern States.

Industrial molasses supplies are obtained from mainland processing of sugar beets, corn (hydrol), citrus, and sugar cane; from inshipments of molasses produced from sugar cane in Hawaii and Puerto Rico; and from imports of molasses produced from sugar cane in Cuba, Mexico, the Dominican Republic, and other countries. The relative importance of these sources of molasses for 1956, taken from Walker (*69*), is given in the following tabulation:

	Million gallons
Mainland production:	
Beet	44.8
Citrus	8.8
Hydrol	17.9
Cane	46.1
Refiners' blackstrap	31.8
Total	149.4

	Million gallons
Inshipments:	
Hawaii	46.5
Puerto Rico	37.6
Total	84.1
Imports:	
Cuba	202.9
Dominican Republic	23.5
Mexico	38.4
Other	76.1
Total	340.9
Grand total	574.4

Of the total supply of 574 million gallons, 10 million gallons were exported, 8 million were used for industrial and food uses, and 406 million were used in mixed feeds, direct feeding, and in silage. The location of the mainland production of beet molasses is approximately that indicated for beet pulp production. Citrus molasses is that reported by the Florida Citrus Processors Association. Domestic production of cane molasses and refiners' blackstrap is mainly in Louisiana, but some is in Florida. Hydrol is obtained from the corn wet-milling industry as a byproduct in the manufacture of corn sugar. Processing plants are located in the Central States. Imports or inshipments are mainly cane molasses.

Hominy feed production is not reported except in recent Censuses of Manufactures. It is produced in the dry-milling of corn which is located mainly in the midwestern States.

A similar situation holds for oat millfeeds production.

Screenings production is largely that from wheat and flax milling; it corresponds to the production areas of these products.

DEMAND FOR HIGH-PROTEIN FEEDS

High-protein feeds are used mainly in manufactured feed rations, especially for poultry, dairy cattle, and hogs. The demand for the various feeds depends on (1) the specifications of these rations, including any ingredient restrictions considered in their formulation and (2) the production functions of the various livestock. A complete study of the demand relationships of the feed factors of production would require knowledge of the production response to various levels of feed inputs and the physical substitution of the various feed ingredients. Since this report is directed toward analysis of demand elasticities obtained from time-series data, it is not feasible to discuss in detail the aspects that relate more directly to nutrition and production economics research. However, some discussion of these considerations is thought to be basic to the interpretation of the demand relationships for feed grains and high-protein feeds.

The actual supply response by producers, which is reflected in feed prices, involves consideration of factors other than those already noted. These include (1) the influence of uncertainty as to product and factor prices; (2) the short-run versus the long-run adjustment

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possibilities to changing conditions; (3) institutional factors, such as those that might influence changes in feed ingredients included in formula feeds; and (4) the influence on timing of livestock production of changes in the ingredient composition of the ration. Thus, even when the basic production response data are known, they will not provide the complete answer to the production adjustment farmers will make with given changes in economic conditions.

PRODUCTION FUNCTIONS FOR VARIOUS KINDS OF LIVESTOCK

Poultry

The economic implications of the production function for egg production are discussed by Hansen and Mighell (*17*). These authors indicate that the maintenance portion of the total ration is a much larger proportion of the total ration for laying hens than for dairy cows, for example. Feeding standards indicate a straight-line relationship between feed inputs and egg production for the production part of the ration. These authors conclude that, although technical research in feeding supports the thesis of diminishing returns present in the feed-egg relationship, practical feeding of laying hens requires full-feeding; that is, the production function does not differ significantly from the straight line of the feeding standards. But important problems arise in the choice (1) of ingredients in mixed poultry rations and (2) between "high efficiency" and "standard" rations.

In a given year, commercial poultry producers normally make adjustments in numbers of layers rather than in quantity fed per layer; these adjustments depend on how profitable egg production is in relation to other production alternatives. Producers also are faced with a decision as to the type of ration to feed; this decision is influenced by the relative production response obtained from the various rations, prices of the feeds, and prices of eggs and poultry meat, as well as other pertinent factors. The quantity of the various feed ingredients used in these feeds depends on these demand and supply conditions for egg production, and also on conditions for other poultry and livestock products.

For broiler production, Hansen and Mighell (*18*) give experimental data that indicate net returns diminish as feed inputs are increased. However, the important production decisions in broiler production include a choice as to the type of ration fed, the number of batches of broilers raised, and the weight at which broilers are sold. The major supply response in broiler production, for a given year, is likely to be in numbers grown rather than in variation in weights at which birds are sold. As the production period for broilers is relatively short, within a given year more adjustment in numbers is possible for broilers than for other livestock products. The derived demand for the various feed ingredients thus depends on (1) the production response obtained from the various rations and (2) the supply response by broiler producers in numbers of birds raised. The demand for individual feed ingredients also depends on the nutritive content of these feeds in relation to the nutritive specifications of the "high efficiency" or "standard" rations.

Substitution of feed ingredients in poultry rations.—We first consider the substitution of feed ingredients in broiler or layer mashes manufactured to meet a given set of nutritive specifications. This involves a determination of a multidimensional iso-product curve, rather than the production response from added feed inputs. One set of assumed minimum specifications of mixed feeds for these mashes is given in table 35, together with the composition of the principal feed ingredients. The feed ingredients are grouped into those valued mainly for their content of (1) protein, (2) energy, (3) minerals, and (4) vitamins, although an inspection of the table indicates that most feed ingredients contain at least some of the other desired characteristics. As shown in the last two columns, certain feeds have limits which are considered desirable by poultry nutritionists as to the quantity to be included in the ration. With given prices of the ingredients, Waugh *(70)* has demonstrated that a minimum cost combination of ingredients meeting a given set of specifications can be obtained by linear programming techniques.

The broiler feed specified in this example is a "high efficiency" ration, with a protein content of 21 percent and a productive energy content of 950 calories per pound. The amount of substitution of ingredients for this ration is more limited than for one with less restrictive specifications. In this feed, soybean meal would be the principal protein and corn the principal energy feed, under most current price relationships. In certain regions of the country, however, other grains or protein feeds might well be substituted to a greater or lesser extent for these feeds. By varying the prices of the ingredients, we can determine the substitution of the several feeds. Assume, for example, that the price of meat scraps declines. As a ration is satisfactory if it contains at least as much of each nutrient as specified, the substitution of meat meal for soybean meal would differ somewhat, depending on the extent to which certain nutritive specifications are over-supplied in the minimum cost ration.

A study by Heady, Balloun, and McAlexander *(20)* indicates the quantity of feed, and the number of days, required to produce broilers to a weight of 1.3 pounds and 3.1 pounds, respectively. In this experiment, the protein content of the ration was varied from 16 to 26 percent by substituting soybean meal for corn. These experimental rations included adequate quantities of minerals, vitamins, and other ingredients. This study differs from the example discussed previously—the protein content of the ration was raised by increasing the amount of soybean meal, the energy content was reduced by decreasing the amount of corn. The rate of substitution of soybean meal for corn decreased as the protein level increased, as shown in table 36. For growth of broilers up to 1.3 pounds, 1 pound of soybean meal replaced 3.35 pounds of corn in a ration of 16 percent protein; whereas in a ration containing 26 percent protein, 1 pound of soybean meal replaced 0.71 pounds of corn. For the heavier-weight broilers, the rate of substitution of soybean meal for corn is lower, that is, the slope of the iso-product curve is flatter, for comparable levels of protein content than for the lighter-weight birds. This reflects the reduced need for protein for larger birds, or conversely, the relative increase in productive energy requirements.

TABLE 35.—*Broiler mash: Assumed minimum specifications of mixed feed, composition of ingredients, and assumed ingredient restrictions, per ton*

Item	Composition of feed																					Assumed ingredient restrictions [1]
	Content			Amino acids					Minerals				Vitamins						Unidentified factors			
	Protein	Nonfiber	Productive energy	Arginine	Lysine	Methionine	Methionine plus cystine	Tryptophan	Calcium	Inorganic phosphorus	Salt	Other	Riboflavin	Pantothenic acid	Niacin	Choline	A	B-12	Fish	Alfalfa	Whey	
	Assumed minimum specification of broiler mash, per ton [2]																					
	Lb.	*Lb.*	*1,000 cal.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Mil. IU*	*Mg.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Broiler mash	420	1,920	1,900	24	18	9	16	4	20	9	5	6	3.12	8.4	24.0	1,440	7	9.6	40	40	40	--
	Composition of ingredients, per ton [3]																					
Ingredient group:																						
Protein:																						
Soybean meal:																						
Solvent, 44%	916	1,884	1,520	64	58	[4] 12.4	[4] 25.6	12	6.4	4.0	0	0	3.0	13.2	24.4	2,494	0	0	0	0	0	--
Without hulls, 50%	1,018	1,914	1,580	--	--	--	--	--	5.2	3.6	0	0	2.8	--	19.6	2,510	0	0	0	0	0	--
Linseed meal, solvent, 34% [5]	702	1,822	1,014	56	26	10	22	10	7.0	5.0	0	0	2.6	--	27.4	1,114	0	0	0	0	0	40
Cottonseed meal, expeller, 41% [6]	828	1,896	1,600	66	32	10	30	10	3.6	6.8	0	0	5.8	11.4	34.0	2,414	0	0	0	0	0	300
Corn gluten meal, 41%	858	1,920	1,642	28	16	20	32	4	3.2	2.4	0	0	1.4	9.4	45.4	300	24.0	0	0	0	0	--
Meat and bone scrap, 50%	1,012	1,956	1,748	8	7	14	26	4	211.4	101.4	0	(7)	4.0	3.4	43.4	1,986	0	80.6	800	0	0	240
Fish:																						
Meal, Menhaden, 60% [8]	1,226	1,986	1,882	80	106	[4] 36	[4] 48	12	109.8	56.2	(7)	(7)	4.4	8.2	50.8	3,326	0	60.0	1,600	0	0	300
Solubles, condensed	628	1,988	--	48	54	20	54	16	12.2	14.0	(7)	(7)	13.2	32.2	153.4	3,662	2.0	590.2	2,000	0	0	100
Dried:																						
Buttermilk	640	1,992	1,572	22	48	14	--	10	26.8	18.8	0	0	28.2	27.4	7.8	1,644	0	16.6	0	0	0	} 200
Skim milk	670	1,996	1,530	24	56	16	26	8	25.2	20.0	0	0	18.2	30.6	10.4	1,294	0	38.0	0	0	0	
Whey, cheese [9]	262	1,994	1,572	4	16	3	9	2	18.0	16.0	0	0	16.2	44.8	10.2	1,828	0	15.2	0	0	2,000	
Brewers' yeast	892	1,946	1,144	44	60	14	24	10	2.6	8.6	0	0	31.8	90.8	406.8	3,532	0	0	0	0	2,000	--
Distillers' solubles, corn	530	1,924	2,040	20	18	12	24	4	7.0	8.0	0	0	7.8	10.0	60.8	2,246	1.0	0	0	0	1,000	--
Distillers' grains, with solubles	514	1,820	1,782	18	14	10	--	2	3.4	4.0	0	0	15.4	19.0	101.8	4,380	5.7	0	0	0	0	--
Methionine supplement	--	--	--	--	--	(7)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Energy:																					
Corn	178	1,960	2,210	8	6	2.8	5.8	1.6	.4	1.8	0	0	1.0	5.2	19.6	---	4.4	0	0	0	0	------
Milo maize	226	1,956	2,198	6	6	3.2	7.2	1.8	.6	1.8	0	0	.8	10.0	26.2	---	-	0	0	0	0	------
Wheat:																						
Hard red winter	304	1,948	1,794	10	8	4.2	9.0	3.2	1.0	2.4	0	0	1.0	12.6	48.2	--	--	0	0	0	0	------
Standard middlings	344	1,848	1,388	18	14	4	8	4	3.0	5.4	0	0	1.8	18.0	89.0	976	4.7	0	0	0	0	------
Hominy feed, yellow corn	222	1,902	1,670	10	8	2	------	2	1.0	3.2	0	0	2.2	7.8	39.2	870	10.3	0	0	0	0	200
Oats, excluding Pacific Coast	240	1,780	[10] 1,620	12	5	2.6	7	2.4	1.8	2.4	0	0	.8	13.6	16.4	--	--	0	0	0	0	------
Barley, excluding Pacific Coast	254	1,892	[11] 1,626	10	6	2.4	6.4	2.6	1.8	.3	0	0	1.6	7.4	48.2	--	-	0	0	0	0	------
Tallow	0	2,000	5,756	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	160
Minerals:																						
Bone meal, steamed	242	1,966	610	0	0	0	0	0	579.6	271.8	0	(7)	.8	2.2	3.6	---	0	0	0	0	0	------
Calcium carbonate	0	0	0	0	0	0	0	0	731.8	0	0	(7)	0	0	0	0	0	0	0	0	0	------
Phosphate:																						
Dicalcium	0	0	0	0	0	0	0	0	540.0	381.4	0	0	0	0	0	0	0	0	0	0	0	------
Defluorinated	0	0	0	0	0	0	0	0	583.6	266.8	0	0	0	0	0	0	0	0	0	0	0	------
Salt	0	0	0	0	0	0	0	0	0	0	2,000	0	0	0	0	0	0	0	0	0	0	10
Mineral supplement	0	0	0	0	0	0	0	0	----	----	----	(7)	0	0	0	0	0	0	0	0	0	------
Vitamins:																						
Alfalfa meal, dehydrated, 17% [12]	356	1,516	434	16	18	6.4	13.2	4.6	34.0	1.2	0	0	14.6	24.6	17.4	--	200.0	0	0	2,000	0	------
Supplements:																						
Riboflavin	----	----	----	----	----	----	----	----	----	----	----	----	(7)	----	----	----	----	----	----	----	----	------
Calcium pantothenate	----	----	----	----	----	----	----	----	----	----	----	----	----	(7)	----	----	----	----	----	----	----	------
Niacin	----	----	----	----	----	----	----	----	----	----	----	----	----	----	(7)	----	----	----	----	----	----	------
Choline	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	(7)	----	----	----	----	----	------
A+D	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	(7)	----	----	----	----	------
B-12	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	(7)	----	----	----	------

[1] Broiler feed specifications, ingredient composition factors, and ingredient restrictions given here represent the cooperative work of nutritionists and economists of the United States Department of Agriculture and the Pennsylvania State University. A more complete explanation of these factors and a minimum cost solution of a broiler mash is given in Hutton, et al. (*24*).

[2] Data relate to minimum specifications except for calcium and inorganic phosphorus which must equal the level indicated. An additional specification relates to the ratio of productive energy (calories per pound) to protein content (percent) which should vary between the limits of 42:1 to 45:1. Also, the mash should include adequate amounts of antibiotics and antioxidants.

[3] Data on ingredient content are from the following sources: Productive energy, Titus (*44*); content of byproduct feeds, National Research Council Publ. 449 (*40*); content of feed grains and alfalfa meal, National Research Council Publ. 301 (*39*). The non-phytin phosphorus content of plant ingredients is taken as 30 percent of the total phosphorus content (*39*, p. 4).

[4] As shown in National Research Council Publ. 301 (*39*).

[5] Values for protein, fiber, amino acid, and folic acid content not specified for solvent meal, and refer to "linseed meal."

[6] Value for productive energy is for "cottonseed meal, 43% protein, 4% fat"; and for amino acids, "cottonseed meal."

[7] Contains varying amount of indicated specification.

[8] Values for productive energy, pantothenic acid, and choline content not specified for Menhaden, and refer to "fish meal"; that for cystine is for "fish meal, 67% protein"; and that for folic acid is for "fish meal, herring."

[9] Values for methionine, cystine, calcium, phosphorus, pantothenic acid, and niacin content not specified for dried cheese whey, and refer to "whey, dried" as indicated in National Research Council Publ. 301 (*39*).

[10] Value for productive energy is for "all oats."

[11] Value for productive energy is for "all barley."

[12] Guaranteed vitamin A content of 100,000 I. U. per pound.

TABLE 36.—*Broiler rations: Combinations of soybean meal and corn which produce 1 pound of gain for broilers of two weights, rates of substitution of feeds, and time required for gain* [1]

Percentage protein in ration	Weight of broilers: Up to 1.3 pounds — Feed per pound of gain: Corn	Soybean meal	Rate of substitution [2]	Total: Feed	Time	1.3 to 3.1 pounds — Feed per pound of gain: Corn	Soybean meal	Rate of substitution [2]	Total [3]: Feed	Time
Percent	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Days*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Days*
16	1.8	0.4	3.35	3.11	45	2.5	0.5	2.75	9.82	83
17	1.6	.4	2.72	2.96	43	2.3	.6	2.23	9.41	80
18	1.5	.5	2.26	2.86	43	2.2	.7	1.86	9.29	79
19	1.4	.5	1.90	2.79	42	2.1	.8	1.56	9.17	78
20	1.3	.6	1.62	2.74	41	2.0	.8	1.33	9.11	77
21	1.3	.6	1.40	2.71	41	1.9	.9	1.15	9.09	77
22	1.2	.7	1.21	2.69	40	1.8	1.0	.99	9.11	77
23	1.1	.7	1.05	2.68	40	1.7	1.2	.87	9.18	77
24	1.1	.8	.92	2.68	40	1.7	1.3	.76	9.28	78
25	1.0	.9	.81	2.70	41	1.6	1.4	.66	9.44	79
26	.9	.9	.71	2.74	41	1.5	1.5	.58	9.62	81

[1] Experimental data as reported by Heady, Balloun, and McAlexander (*20*).
[2] Pounds of corn replaced by an additional pound of soybean meal.
[3] From starting time to a weight of 3.25 pounds.

These data indicate that the time required for growth decreases as the protein level is increased up to a certain point, and then increases for very high levels of protein content, with corresponding changes in the energy level in the opposite direction. The decision as to the type of feed to be used to produce broilers depends on the prices of the various ingredients, the total feed requirements, the rates of substitution between the various feeds, and the time required for growth.

Influence of nutritional developments.—Nutritional advances, over time, have influenced the relative importance of feed ingredients in poultry and livestock rations. Before the amino acid methionine was produced synthetically, for example, it was necessary to add feeds rich in this nutrient in order to meet the requirement. Currently, other feeds can be used to a greater extent if supplemented with synthetic methionine.

The isolation of vitamin B-12 and its subsequent synthetic production is another illustration of the impact of nutritional advances on the relative prices of certain byproduct feeds. A recent report on broiler nutrition by the Agricultural Research Service (*57*, p. 6) describes this development as follows: "For a long time it was known that chicks would not grow properly on vegetable protein alone, even if the rations were supplemented with those amino acids the vegetable proteins happened to be deficient in. But the inclusion of an animal protein seemed to correct the apparent deficiency. Accordingly, researchers referred to the quality of animal proteins that rendered them superior to vegetable proteins as the 'Animal Protein Factor' or APF. Other workers, searching for the factor in liver that prevented or cured pernicious anemia, successfully isolated a cobalt-containing substance which is called B-12. Feeds containing only vegetable proteins (such as soybean meal enriched with methionine), but supplemented with B-12, gave growth results comparable to feeds containing animal proteins. It was therefore concluded that vitamin B-12 was the main constituent of APF. Since then the term, APF, has fallen into disuse." Vitamin B-12 currently is used widely in manufactured poultry feeds, as reported by Brensike (*7*).

Currently, poultry nutritionists refer to three unidentified factors in broiler nutrition; namely, the "fish," "whey," and "alfalfa" factors. The ARS report (*57*, pp. 6-7) indicates that the "fish factor" is thought to be present in fish meal, fish solubles, crab meal, meat byproducts, liver preparations, and certain fermentation products. The "whey factor" is thought to exist in dried distillers' solubles, dried brewers' yeast, butyl fermentation solubles, dried whey products, and certain fermentation products. The "alfalfa factor" is thought to exist in dehydrated alfalfa leaf meal, grass juice concentrate, and dried brewers' yeast. The broiler ration specified in table 35 allows for the inclusion of these unidentified factors, but the requirements are rough approximations at this time. Further research may isolate these "factors;" the nutritive specifications then will change accordingly.

Antibiotics are included in most manufactured poultry rations at this time, as reported by Brensike (*7*). The use of antibiotics was an outgrowth of the synthetic production of vitamin B-12. This development is described in the ARS report (*57*, p. 7) as follows: "Subsequent work provided that another growth-promoting factor was present in the crude sources of B-12. When isolated, it proved to be the antibiotic aureomycin. Its beneficial effect was attributed to its ability to control inapparent or low-grade infections. When the inapparent infections were brought under control, increased growth, greater feed efficiency, and lower mortality usually followed. Similar benefits were attributed to the use of terramycin, penicillin, and bacitracin. As a result, most commercial broiler rations include minute amounts of one of the antibiotics or a mixture of two or more. Higher levels of antibiotics (100 to 250 grams per ton) appear to be of value in reducing mortality and restoring birds to a healthy condition during outbreaks of many diseases."

Other ingredients sometimes added to poultry feeds include antioxidants, arsenicals, and hormones. *Antioxidants* are chemical preservatives that are included to retard the rancidity of added fats and to reduce the loss of the fat-soluble vitamins (A, D, E, K). *Arsenicals* are used as growth stimulants. As indicated in the ARS report (*57*, pp. 7–8), "although toxic at higher levels, they have been used as tonics for a number of years. Their inclusion in broiler rations is relatively recent, and it is thought that the manner in which they attain their beneficial effects is similar to that of the antibiotics. Some research workers, however, doubt that arsenicals provide a growth response in addition to that given by antibiotics." *Hormones* are used sometimes in producing certain meat-type birds.

Use of the protein and energy feed ingredients in various poultry rations depends not only on the level of demand for poultry products, but on the demand for various livestock products. The specifications for complete rations or protein supplements for dairy cattle, hogs, beef cattle, and other livestock differ from those for poultry feeds. As indicated previously, poultry feeds are the most important item in terms of tonnage of manufactured feeds, with shipments in 1954 of 15.4 million tons, compared with 4.7 million tons of dairy feeds, 2.3 million tons of hog and pig feed, and 1.5 million tons of beef and range cattle feed, as reported by the Census (*63*). Manufactured feeds do not account for as large a percentage of the total ration for livestock as for poultry. However, the derived demand for protein supplements for livestock production exerts an important influence on the demand for protein feeds, and especially for the energy feeds, and thus tie in the demand for protein feeds with the overall feed-livestock complex.

Dairy

Hay, silage, and pasture account for roughly 75 percent of the total tonnage of feed consumed by dairy cattle, in contrast with the rations of poultry and hogs which consist mainly of concentrates. The protein content of the dairy concentrate fed can be varied according to the protein content of the roughage. Moore (*36*, p. 5) points out that "in general, it is recommended that where the forage part of a ration consists of poor-quality grass hay, the grain mixture should contain about 20 to 24 percent of protein; where the forage is mixed hay, about 16 to 18 percent; and where the forage is good-quality legume hay, 12 to 14 percent."

The most profitable level of grain feeding depends on such factors as the quality and quantity of roughage, the productive capacity of the cow, and on economic considerations such as the price of the various feeds and of milk. In contrast with eggs, input-output relationships in milk production, reported by Jensen, et al. (*29*), follow a law of diminishing physical output. That is, although milk production increases as the grain allowance is increased, the additional milk produced for each additional unit of grain decreases. But the response varies with the quality of roughage and the productive capacity of the cow. These experiments were conducted with varying levels of grain feeding but with free feeding of roughage. Further experiments on feeding of dairy cattle to measure the substitution relationships among the various feed inputs are required for more exact conclusions as to the demand relationships for cattle feeding.

Nutritional specifications for dairy cattle rations include such factors as digestible protein, total digestible nutrients, certain minerals, and vitamins. Protein requirements are simpler for ruminants than for poultry and pigs; in ruminants simple nitrogenous compounds are converted to complete proteins by bacterial action. Urea thus can be used in ruminant rations. Moore (*36*, p. 6) points out that "ruminants, which have four stomachs, are able to convert it (urea) to amino acids and protein. The protein is stored in the bacteria and becomes available to the host animal as the bacteria are digested during their passage from the paunch into the true stomach and intestines. Most all of the experimental data show quite definitely that urea is not effective when added to high-protein grain rations for milk production purposes. Thus, urea should not be added to grain rations already containing 14 to 18 percent protein. It is most effective when added to grain rations containing 10 percent or less of protein, such as home-grown grains. It appears that when urea is added to a mixture containing 10 to 11 percent of protein, it may be utilized to the extent of 40 percent or less." Requirements other than those of a strictly nutritive nature, such as palatability, must be considered in formulating mixed feeds. Other considerations in producing feeds under mill-operating conditions are described by Hutton and Allison (*23*). These authors point out how these restrictions may be introduced in determining minimum cost rations meeting nutritive and operational specifications by means of linear programming techniques.

Hogs

Economic considerations in the production of hogs are given in two basic research bulletins by Atkinson and Klein (*3*, *4*). These authors (*4*, p. 3) indicate that, as hogs are grown to increasingly heavier weights, "four changes take place which demand consideration in a study of the efficiency of hogs in converting feed into food: (1) The feed required per pound of gain in liveweight increases, (2) the dressing percentage increases, (3) the proportion of edible product increases relative to skin and bone, and (4) the proportion of fat increases relative to the lean." The price received per hundredweight for hogs of various weights reflects the last three points. The type of relationship between feed inputs and weight gain is illustrated in table 37, based on data given in a National Research Council report on swine nutrition (*38*, pp. 2–3). As weight is increased, the feed required per pound of gain increases, as indicated in the third row of this table. These data indicate a constant percentage content of total digestible nutrients in rations for all weight groups. But the protein requirements decrease from 18 percent of the ration for 25-pound pigs to 12 percent for 200-pound pigs. This decrease in protein requirements is characteristic for other livestock and poultry.

TABLE 37.—*Nutrient requirements for swine: Expected daily gain and composition of ration for various weight pigs*

Item	Unit	Liveweight of market stock, pounds					
		25	50	100	150	200	250
Expected daily gain	Lb	0.8	1.2	1.6	1.8	1.8	1.8
Total fed daily	Lb	2.0	3.2	5.3	6.8	7.5	8.3
Feed per pound of gain	Lb	2.5	2.7	3.3	3.8	4.2	4.6
Total digestible nutrients.	Pct	.75	.75	.75	.75	.75	.75
Crude protein	Pct	18.0	16.0	14.0	13.0	12.0	12.0
Inorganic nutrients:							
Calcium	Pct	.8	.65	.65	.55	.55	.55
Phosphorus	Pct	.6	.45	.45	.33	.33	.33
Salt (NaCl)	Pct	.5	.5	.5	.5	.5	.5
Vitamins:							
Carotene	Mg	.25	.31	.38	.44	.53	.60
Vitamin D	I. U	90.0	90.0	90.0	90.0	90.0	90.0
Thiamine	Mg	.5	.5	.5	.5	.5	.5
Riboflavin	Mg	1.2	1.0	1.0	1.0	1.0	1.0
Niacin	Mg	8.0	6.0	5.0	5.0	5.0	5.0
Pantothenic acid	Mg	5.0	5.0	4.5	4.5	4.5	4.5
Pyridoxine	Mg	.6	.6				
Choline	Mg	400.0					
Vitamin B-12	Mcg	7.0	5.0	5.0			

Nutrient Requirements for Swine (*38*, pp. 2–3).

These data indicate the general feed requirements for hog production. But in this study we are interested in the demand relationships between protein feeds and the feed grains. Data reported by Heady, Woodworth, Catron, and Ashton (*19*) are useful in this respect. These authors give results of experiments in growing hogs to various weights with various levels of soybean meal and corn in the ration. These rations were formulated to include other feed ingredients, such as minerals, vitamins, and antibiotics. These data, shown in table 38, indicate the feed required per 100 pounds of gain with varying levels of protein and energy in hog rations. Data on the time required for growth are given in table 39. These data on hog production are taken to illustrate the nature of the derived demand for feed inputs under certain restrictive conditions.

TABLE 38.—*Pig rations: Combinations of soybean meal and corn which produce 100 pounds of gain for pigs of three weights and rates of substitution of soybean meal for corn* [1]

Weight of pigs, pounds											
34–75				75–150				150–200			
Feed per 100 pound gain		Marginal rate of substitution [2]	Protein in total ration [3]	Feed per 100 pound gain		Marginal rate of substitution [2]	Protein in total ration [3]	Feed per 100 pound gain		Marginal rate of substitution [2]	Protein in total ration [3]
Soybean meal	Corn			Soybean meal	Corn			Soybean meal	Corn		
Pounds	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Pounds*	*Percent*
10	422	23. 5	9. 1	10	357	6. 6	9. 3	10	387	4. 2	9. 2
15	337	12. 5	9. 8	15	336	4. 2	9. 8	15	371	2. 7	9. 7
20	287	8. 0	10. 6	20	319	3. 0	10. 4	20	359	1. 9	10. 2
25	253	5. 6	11. 5	25	306	2. 3	11. 0	25	351	1. 5	10. 7
30	229	4. 3	12. 4	30	295	1. 8	11. 6	30	342	1. 2	11. 2
35	210	3. 3	13. 4	35	298	1. 5	12. 2	35	338	1. 0	11. 6
40	195	2. 7	14. 4	40	281	1. 3	12. 7	40	333	. 9	12. 1
45	182	2. 3	15. 3	45	275	1. 1	13. 3	45	329	. 8	12. 6
50	172	1. 9	16. 3	50	269	1. 0	13. 9	----	----	----	----
55	163	1. 7	17. 3	55	264	. 9	14. 4	----	----	----	----
60	155	1. 4	18. 2	60	260	. 8	15. 0	----	----	----	----
65	149	1. 3	18. 5	----	----	----	----	----	----	----	----
70	143	1. 1	20. 0	----	----	----	----	----	----	----	----
75	137	1. 0	20. 9	----	----	----	----	----	----	----	----

[1] Data presented by Heady, Woodworth, Catron, and Ashton (*19*, p. 944). The feed quantities were derived for the gains necessary to take a pig from the beginning of the specific interval to weights of 60, 110, and 175 pounds, respectively. These quantities were then transformed to the equivalent of a 100-pound gain. These results are for a ration containing aureomycin in addition to various minerals and vitamins.

[2] Pounds of corn replaced by one pound of soybean meal.

[3] Soybean meal contained about 45 percent protein and corn 8.4 percent in experiment number 554 and 7.2 percent in experiment number 536. Data from these two experiments were pooled in this particular analysis, but results from each experiment also are presented in the original report (*19*).

TABLE 39.—*Pig rations: Total days required for gains for four weight intervals, with varying protein content in ration* [1]

Percentage protein in ration	Weight of pigs, pounds			
	34–75 (41 pound gain)	75–150 (75 pound gain)	150–225 (75 pound gain)	34–225 (191 pound gain) [2]
Percent	*Days*	*Days*	*Days*	*Days*
10	51	53	46	151
11	41	46	40	127
12	38	44	38	120
13	34	42	36	113
14	33	42	36	111
15	31	42	36	108
16	30	42	36	108
17	29	43	38	110
18	28	44	40	112
19	28	47	44	118
20	28	48	46	122

[1] Data presented by Heady, Woodworth, Catron, and Ashton (*19*, p. 953), for ration which includes aureomycin.
[2] Assumes that the same ration is fed continuously.

THE DERIVED DEMAND FOR FEED INPUTS

Feeds are purchased as factors of production for producing livestock and the demand for them depends directly on the demand for the various livestock products. The demand curve for feeds is directly related to the output of livestock products that may be obtained with varying levels of feed inputs. More specifically, the price of a given feed, under competitive equilibrium, is equal to the price of the livestock product multiplied by the marginal productivity of that feed. For an individual producer the demand curve for feed can be derived by assuming a given price of livestock products, and by determining the most profitable level of feed input associated with specified levels of feed prices. The market demand for feed must reflect the equilibrium feeding rate by producers, allowing for changes in the prices of livestock products resulting from increased or decreased output of livestock products. Shifts in the demand curve for livestock products will be reflected back to the demand for feed inputs.

To simplify the presentation, the following discussion refers to adjustments in rates of feeding on individual farms. A more complex formulation would be required to allow for the various types of livestock products and regional considerations. Even in this simple case, important assumptions have to be introduced, and the results should be considered as useful only for purposes of illustrating the nature of the demand for feed inputs.

Assume that the production function for hogs is as follows: [5]

$$X = \varphi\,(C, S) \tag{1}$$

where X represents the weight of hogs, and C and S represent the quantities fed of corn and soybean meal, respectively. Assume that these are the only variable inputs.

The isoproduct curves on this production function are of the type presented by Heady, et al. (*19*), and any isoquant can be expressed as:

$$X_1 = \varphi(C, S) \tag{2}$$

Taking the differential of this function and setting it equal to zero, we get:

$$0 = \varphi_C dC + \varphi_S dS \tag{3}$$

or

$$\frac{dC}{dS} = -\frac{\varphi_S}{\varphi_C} \tag{4}$$

which is the well-known relationship that the slope of the isoquant at any point equals the ratio of the marginal productivities. The change in the slope of the isoquants as the quantity of one feed is increased, holding the quantity of the other constant, is given by the second derivatives:

$$\frac{\partial}{\partial S}\left(\frac{dC}{dS}\right) = -\frac{\varphi_C\varphi_{SS} - \varphi_S\varphi_{SC}}{\varphi_C{}^2} \tag{5}$$

and

$$\frac{\partial}{\partial C}\left(\frac{dC}{dS}\right) = -\frac{\varphi_C\varphi_{SC} - \varphi_S\varphi_{CC}}{\varphi_C{}^2} \tag{6}$$

The change in the slope along a given isoquant is given by:

$$\frac{d^2C}{dS^2} = \frac{\partial}{\partial S}\left(\frac{dC}{dS}\right) + \frac{\partial}{\partial C}\left(\frac{dC}{dS}\right)\cdot\frac{dC}{dS} \tag{7}$$

From equations (5) and (6) we may substitute and get:

$$\frac{d^2C}{dS^2} = -\frac{\varphi_{SS}\varphi_C 2 + 2\varphi_{SC}\varphi_S\varphi_C - \varphi_{CC}\varphi_S 2}{\varphi C^3} \tag{8}$$

Thus, a close relationship exists between the isoquant pattern and the properties of the marginal productivities of the feed inputs.

If we assume that the prices of these feeds are considered fixed by individual producers attempting to maximize profits, we can proceed readily. The isocost curves are then straight lines, that is,

$$P_c \,.\, C + P_s \,.\, S = \text{a constant cost} \tag{9}$$

[5] This presentation follows that of Carlson (*8*). Readers who are unacquainted with calculus may wish to skip to p. 73. There the results are discussed in terms of graphs.

where P_c and P_s represent prices of corn and soybean meal, respectively; and C and S represent quantities of these feeds. If we differentiate this function, we get:

$$\frac{dC}{dS} = -\frac{P_s}{P_c} \tag{10}$$

which indicates that the isocosts are straight and parallel lines with a negative slope equal to the relationship between the given feed prices.

Equating the slopes of the isoquants and the isocost curves, we generate an expansion path along which the marginal productivities of the two feeds are proportional to their prices, or:

$$\frac{\varphi_S}{\varphi_C} = \frac{P_s}{P_c} \tag{11}$$

In determining the scale of output, we consider the behavior of a firm which maximizes profits by equating marginal cost and marginal revenue. The total cost, in this simplified development, is given as follows, where K represents all other costs which are considered as fixed:

$$TC = P_cC + P_sS + K \tag{12}$$

and the marginal cost of an additional output (x) is given by:

$$\frac{dTC}{dx} = \frac{P_cdC + P_sdS}{dx} \tag{13}$$

However, if we assume that feed prices are considered as given by the individual producer, the price of the feed represents the marginal unit cost of that feed, and this is equal to the cost-productivity ratio [6] of the feed multiplied by its marginal productivity, or:

$$P_s = {}_xU_S \cdot \varphi_S \tag{14}$$

But the cost-productivity ratios of the two feeds are equal on the expansion path, and we may write marginal cost as:

$$\frac{dTC}{dx} = {}_xU_S \, \frac{\varphi_S \cdot dS + \varphi_C \cdot dC}{dx} \tag{15}$$

and, since the sum of the marginal products equals d x, we can write:

$$MC = {}_xU_S = {}_xU_C \tag{16}$$

That is, at any point on the expansion path, the marginal cost (MC) of output is equal to the cost-productivity ratio of soybean meal (${}_xU_S$) and corn (${}_xU_C$).

[6] The cost-productivity ratio is defined as the marginal unit cost of a factor divided by the marginal productivity of that factor, or ${}_xU_s = \frac{U_S}{\varphi_S}$.

To maximize profits from hog production, we set marginal revenue equal to marginal cost. In this case marginal revenue (MR) is the increase in revenue obtained from an added pound of hog weight, or the price per pound for hogs (P_h). Thus, we may express the following relationships:

$$MR = P_h = MC = {}_xU_S = {}_xU_C \qquad (17)$$

Also, from equations (14) and (17) we get:

$$P_s = {}_xU_S \cdot \varphi_S \qquad (18)$$

$$= P_h \cdot \varphi_S \qquad (19)$$

$$\text{and } P_c = P_h \cdot \varphi_C \qquad (20)$$

which expresses the relationship that the price of the factor equals the price of the output multiplied by the marginal productivity of that factor.

The theoretical considerations that are stated above indicate the necessity of knowing the shape of the entire production function. Such functions are presented by Heady, et al. (*19*) with several alternative statistical functions fitted to the observations. The following graphic derivation of the demand for corn is based primarily on these data; however, some arbitrary assumptions are introduced to simplify the presentation. We assume that a farmer has hogs weighing 125 pounds and that he is faced with deciding the most profitable weight at which to market these animals. The data given in table 38 for feeding hogs from 150 to 200 pounds are used to generate a series of isoproduct contours, assuming that the same marginal rate of substitution between corn and soybean meal holds for hogs weighing from 125 to 258 pounds.[7] This production function for hogs is given in figure 3. Lines are drawn through the origin representing rations with a given protein content. With the assumption of equal marginal substitution rates within this weight interval, these lines also represent isoclines, or lines along which the ratio between the marginal productivities of the two feeds are equal. The line indicated as 1.5, for example, represents a ration of 10.7 percent protein content, and is the locus of points for which the slope of the isoquants equal 1.5. This slope equals the inverse ratio of the marginal productivities of these feeds, as indicated in equation (4). Since the ratio of prices is equated to the ratio of marginal productivities (equation (10)), this line also represents the applicable expansion path when the price per ton for soybean meal is 1.5 times the price per ton for corn.

Isoquants are drawn in figure 3 for equal feed increments. The weight of hog associated with these isoquants, as indicated in figure 3, are based on the feeding efficiency assumptions given in table 40.

To determine the most profitable level of feeding, revenue and cost curves must be obtained. The price of hogs per hundredweight varies with the weight of the animal, as indicated in table 41. The

[7] The logarithmic function fitted to the data, and upon which the data in table 38 are based, introduces the implicit assumption that the marginal substitution rates are equal within a given weight interval, as pointed out by Heady, et al. (*19*, p. 945).

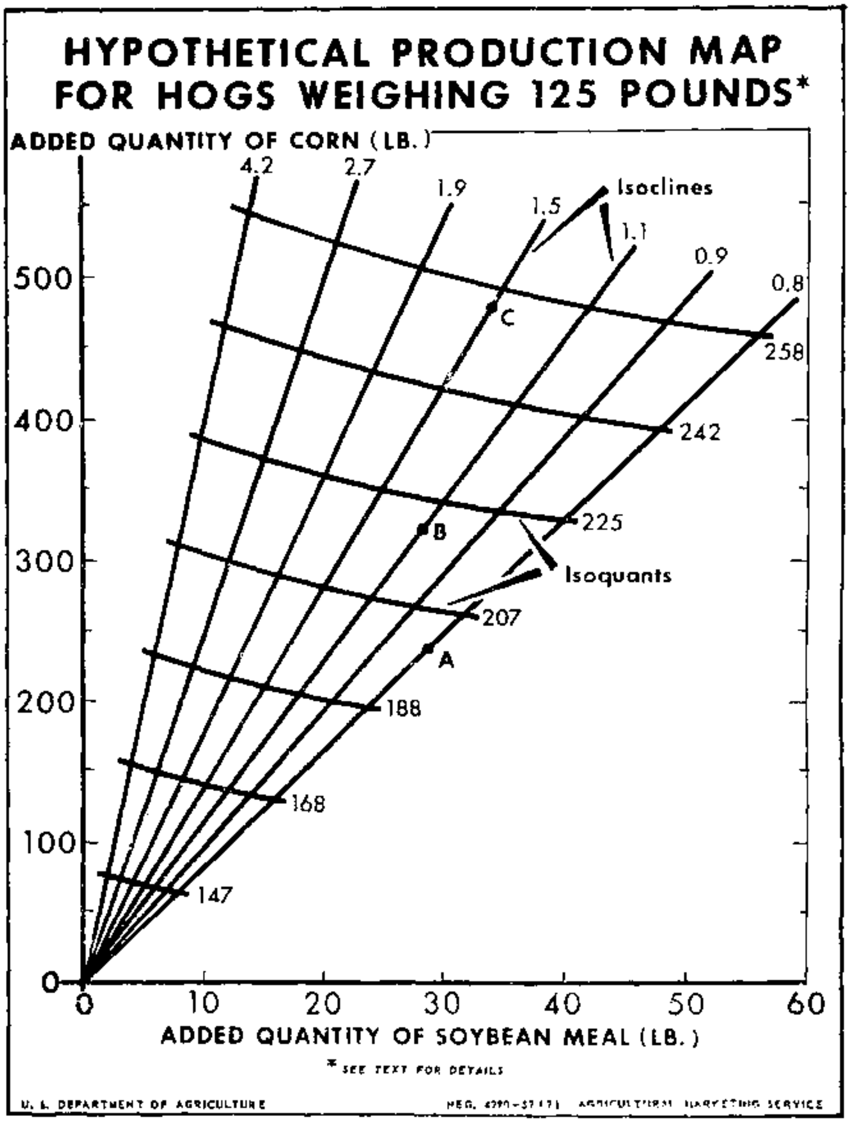

Figure 3.—This hypothetical production map for hog production indicates the quantities of soybean meal and corn required by a 125-pound hog to attain the indicated weight levels. Various isoquants show the marginal substitution rates of corn for soybean meal. Lines radiating from the origin represent rations with constant percentage protein content. With the assumption of equal marginal substitution rates within the weight interval, these lines also represent isoclines, or lines along which the ratio between the marginal productivities of the two feeds are equal. Points A, B, and C represent most profitable weight levels for given feed and hog prices (see figure 4). These relationships are only rough approximations used to illustrate the nature of the demand for feed inputs.

TABLE 40.—*Hogs: Hypothetical production response from an increment of feed of 75 pounds* [1]

Increment of feed	Weight of hog		Increment of feed	Weight of hog	
	Added	Total		Added	Total
	Pounds	*Pounds*		*Pounds*	*Pounds*
1st	22	147	5th	18	225
2d	21	168	6th	17	242
3d	20	188	7th	16	258
4th	19	207			

[1] Assuming a ration of 10.7 percent protein content consisting of 70 pounds of corn, 5 pounds of soybean meal, and small quantities of minerals, vitamins, and aureomycin. The weight gain for the third increment of feed approximates that obtained from the production function equation (C–1–a) presented by Heady, et al. (*19*, p. 924) for 150-pound hogs. The other data on weight gains are rough approximations of the diminishing productivity of feed inputs, and are presented for illustrative purposes only.

shape of the revenue curve is obtained from these data, as shown in figure 4. To obtain cost curves, the price of soybean meal is held constant at $75 per ton. The cost curve associated with a price ratio of 1.5 is obtained by taking the price of corn at $50 per ton, and obtaining the total additional feed cost associated with growing the hog to the various weights indicated on the production function. For example, to attain the weight of 207 pounds, under these assumptions, 20 additional pounds of soybean meal and 280 additional pounds of corn are required. In addition to these costs, an allowance of 15 percent is made for other associated costs. These cost data are summarized in table 42, and the cost curves are plotted in figure 4.

TABLE 41.—*Hogs: Hypothetical revenue function*

Weight of hog	Price relative (200–219 pound hog=100) [1]	Assumed price per hundredweight [2]	Calculated revenue [3]
Pounds	*Percent*	*Dollars*	*Dollars*
160–179	95.5	19.10	32.50
180–199	99.6	19.92	37.85
200–219	100.0	20.00	42.00
220–239	99.5	19.90	45.75
240–269	97.6	19.52	49.50

[1] Average of the relative price per hundred pounds of the specified weight hog to the price of 200–220 pound hogs: Barrows and gilts, Chicago, 1951–55.
[2] Price of a 210-pound hog assumed to be $20 per hundred pounds.
[3] Calculated for median-weight.

454045—58——6

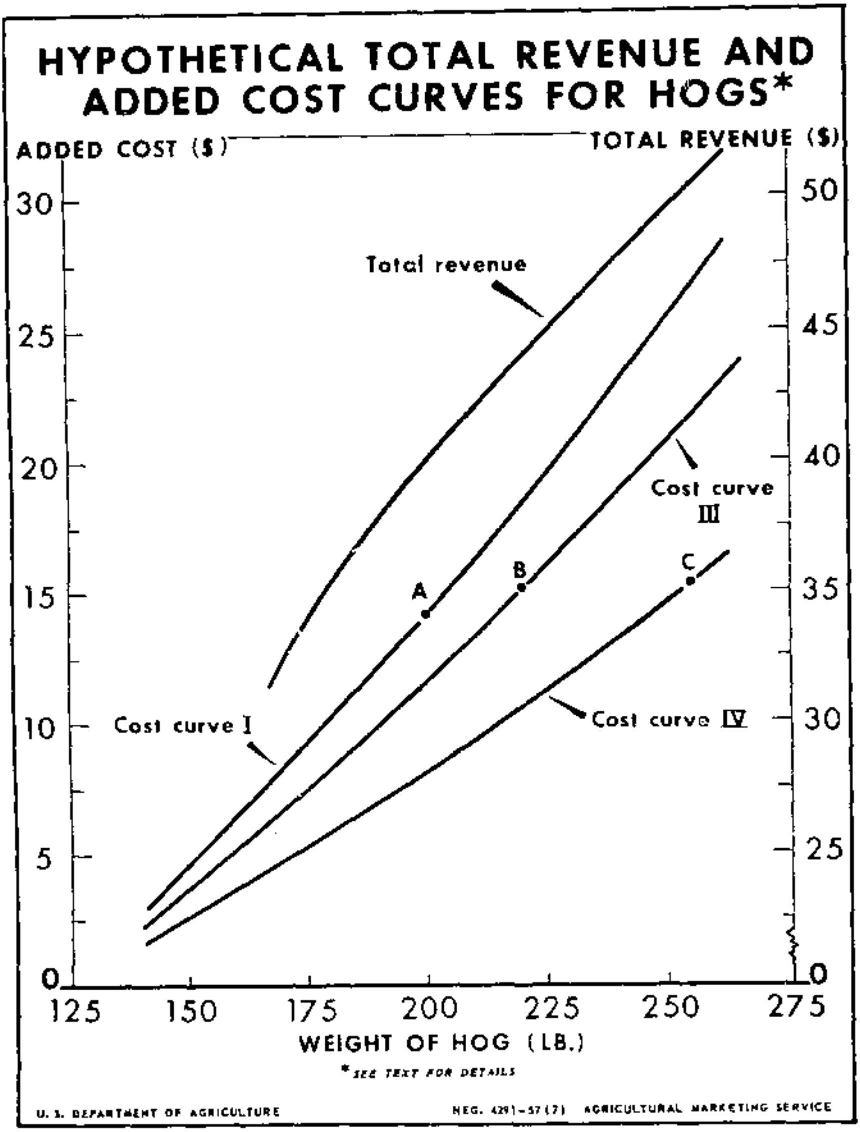

Figure 4.—The most profitable weight to market hogs depends mainly on the prices of feeds and hogs. The price of hogs per hundred pounds varies with market weight, as reflected in the hypothetical total revenue curve. The feed costs associated with raising hogs from 125 pounds to various market weights are indicated for three levels of corn prices, with soybean meal price constant. The quantity of feed associated with these three price ratios are taken from the isoclines in figure 3. Points A, B, and C are the maximum profit weights for the assumed feed and hog prices, in this hypothetical situation.

TABLE 42.—*Hogs: Hypothetical additional feed cost curve*

Cost curve	Price of corn per ton [1]	Additional feed cost to attain weight in pounds of [2]—						
		147	168	188	207	225	242	258
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
I	93.75	3.90	7.80	11.70	15.60	19.50	23.40	27.30
II	83.30	3.55	7.10	10.65	14.15	17.70	21.25	24.80
III	68.40	3.20	6.35	9.55	12.75	15.95	19.10	22.30
IV	50.00	2.25	4.45	6.70	8.95	11.15	13.40	15.65
V	39.60	1.80	3.60	5.40	7.20	9.05	10.85	12.65
VI	27.85	1.30	2.60	3.95	5.25	6.55	7.85	9.20

[1] Price of soybean meal constant at $75 per ton. For cost curve IV, for example, the price of corn is $50 per ton, giving a price ratio of 1.5. The feed fed with this price ratio is taken from isocline 1.5 in figure 3.

[2] Includes an allowance of 15 percent above cost of corn and soybean meal to allow for other associated costs. See Atkinson and Klein (*8*, p. 17).

The most profitable level of feeding for the various prices of corn is the point at which the marginal revenue (the slope of the revenue curve) equals the marginal cost (the slope of a given cost curve). For a price of corn of $93.75 per ton (as shown by cost curve I), the hog would be raised to a market weight of 200 pounds (point A in figure 4). Similarly, for a price of corn of $68.40 per ton (as shown by cost curve III), the hog would be raised to a market weight of 220 pounds (point B); and for a price of corn of $50 per ton (as shown by cost curve IV) the hog would be raised to a market weight of about 255 pounds (point C). If these points are plotted on the production function, as in figure 3, we can read off the quantity of corn associated with the various prices of corn.

The demand curve for corn, relating only to the feeding of hogs to market weight under the various assumptions, can be obtained directly from these data. With a corn price of $93.75 per ton, these data indicate that hogs would be fed 225 pounds of corn in addition to that required for growth to the weight of 125 pounds liveweight. With a price of $68.40 per ton, 310 pounds of corn would be fed; and with a price of $50 per ton, 460 additional pounds of corn would be fed. These data are plotted in figure 5. The elasticity of demand of this curve, estimated by an arc elasticity formula[3] for the range between points B and C, is 1.2, which is more elastic than that usually considered applicable for the total demand for corn. It is emphasized that this formulation is based on several assumptions which cannot be substantiated; it is used only to illustrate the nature of the demand for feed inputs in a rough way.

[3] This formula, given by Boulding (*5*, p. 143), is as follows:

$$\frac{p}{q+\Delta q}\cdot\frac{\Delta q}{\Delta p}$$

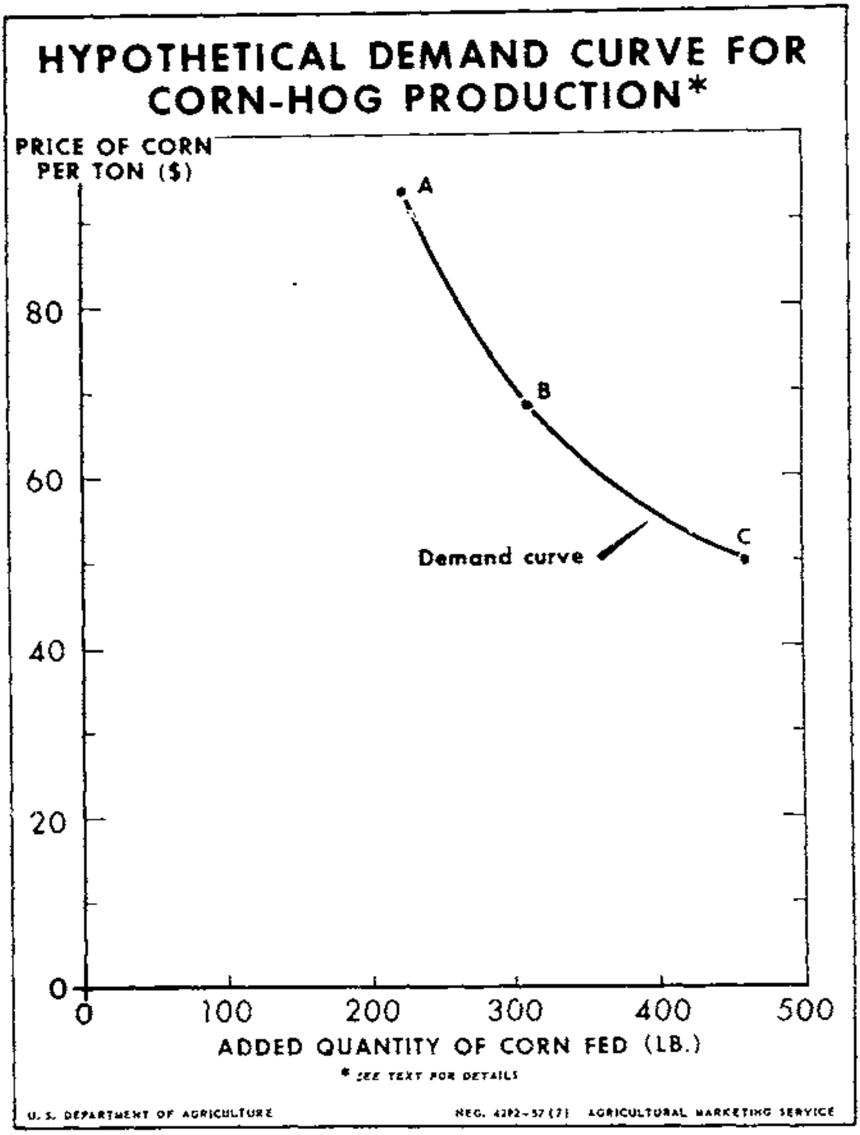

FIGURE 5.—The demand for corn for hog production depends on the basic production function. With given prices of other feeds and the price per hundred pounds for various weight hogs, the demand for corn may be obtained by determining the most profitable weight of hogs with varying prices of corn. The arc elasticity of demand between points B and C on the above curve is 1.2, based on the hypothetical data presented in figures 3 and 4 and discussed in the text.

This formulation relates to hog feeding only. Under the conditions of competitive equilibrium, however, these feeds are used in the various livestock rations in such a way that the following relationships hold:

$$\frac{P_s}{P_c}=\frac{\varphi s\ (\text{hogs})}{\varphi c\ (\text{hogs})}=\frac{\varphi s\ (\text{broilers})}{\varphi c\ (\text{broilers})}=\frac{\varphi s\ (\text{other livestock})}{\varphi c\ (\text{other livestock})} \qquad (21)$$

This equation states that the ratio of prices equals the ratio of marginal productivities in each livestock ration. With given supplies of these two feeds, prices are so determined that these relationships hold, with the utilization among various livestock rations depending on the price of the given livestock product, the number of animals available for feeding, and the associated production functions. The analysis of the aggregate demand for high-protein feeds and for feed grains, with livestock prices combined in one index and with animal numbers similarly combined, averages out many of the details of the demand structure for feeds. But at the time this research study was completed, lack of information as to the individual production functions and related data left no alternative to the aggregative approach.

AN ECONOMIC MODEL RELATING TO THE DEMAND FOR HIGH-PROTEIN FEEDS

The economic factors that determine the demand for high-protein feeds are much the same as those for feed grains. The special characteristics of high-protein feeds, however, warrant the formulation of a model of the demand for feed concentrates that differentiates between these feeds and the feed grains. This model does not attempt to specify all of the relationships involved in the feed-livestock economy, and several simplifying assumptions are introduced. Further research on the demand and supply of individual livestock products is planned; this will allow a more complete model to be developed at a later date.

Condition of range land, pastures, and the quantity and quality of all roughages are important factors that affect the demand for feed concentrates, especially by sheep, beef cattle, and dairy cattle. These factors are not included in our analysis because adequate data are not available. Further, all poultry and livestock numbers are aggregated into one variable—grain-consuming animal units. Thus, increases or decreases in livestock inventories, which are associated with below or above "normal" production of livestock products with a given feed input, are not considered. Similarly, an index of prices of all livestock and livestock products is used.

In general terms, the demand functions for high-protein feeds and for feed grains may be expressed as follows:

$$Q\text{–hpf} = f_1\ (P\text{–hpf},\ P\text{–c},\ P\text{–L},\ AU) \qquad (22)$$

$$Q\text{–fg} = f_2\ (P\text{–hpf},\ P\text{–c},\ P\text{–L},\ AU) \qquad (23)$$

where Q–hpf and Q–fg represent appropriate quantity variables for high-protein feeds and feed grains; P–hpf and P–c represent the respective prices of these feeds; P–L represents the price of livestock and livestock products; and AU represents the number of grain-consuming animal units.

Data on feed utilization and animal units relate to the October-September feeding year. The price of corn is taken to represent the price of feed grains, an assumption used in previous studies (*12*). The November-May average price is used; by November, the price of corn has adjusted to a new-crop basis in most years, and by June and July, the price begins to reflect the outlook for the coming crop. For comparability, the November-May average is used for the price of high-protein feeds.

Operation of the support program for feed grains introduces complications in statistical estimation of these relationships in some years. An analysis of some of the effects of the support program on the price of feed grains, by King (*31*), provides one approach for introducing these factors. This method is used in the following development.

FORM OF AND RESULTS FROM A STATISTICAL MODEL

Several statistical models were formulated to estimate the demand relationships for high-protein feeds and feed grains. The first is a recursive approach which utilizes previous research on the estimation of quantities of current-crop grain placed under loan in a given marketing year. The other models are modifications of this; principal differences are confined to varying the time periods covered by the analysis and transformations of the basic data.

Estimation of the demand coefficients for relations (22) and (23) require special consideration of the supply variable for feed grains for years in which the support program exerted an important influence on prices. The following equations were formulated to allow the estimation of the demand coefficients from the reduced-form equations:[9]

$$\text{Q–s: P–s, Q–t, P–L, AU}, u_1 \qquad (24)$$

$$\text{P–hpf: Q–hpf, Q–r}-\text{Q–s, P–L, AU}, u_2 \qquad (25)$$

$$\text{P–c: Q–hpf, Q–r}-\text{Q–s, P–L, AU}, u_3 \qquad (26)$$

[9] Equation (24) is the equivalent of the partially reduced-form equation C in the following model, which is described in more detail in Friedman and Foote (*15*, pp. 73–74):

$$\log \text{P–f} = \log \text{Q–t} + \log \text{P–L} + \log \text{AU} \qquad (A)$$

$$\log \text{Q–s} = \log \left[\frac{\text{P–f}}{\text{P–s}}\right] = \log \text{P–f} - \log \text{P–s} \qquad (B)$$

$$\log \text{Q–s} = \log \text{Q–t} + \log \text{P–L} + \log \text{AU} - \log \text{P–s} \qquad (C)$$

where P–f represents the price which would have prevailed had there been no support program.

The use of reduced form equations, such as (25) and (26) is described by Foote (*11*, pp. 984–988).

where Q–t = Total supply of feed concentrates, including total stocks of corn and sorghum grains on October 1, and of oats and barley on July 1, production of the four feed grains imported grains, domestic wheat and rye fed, and byproduct feeds fed, *minus* stocks owned by CCC plus old-crop grain resealed as of May 31 for corn and March 31 for oats, barley and sorghum grains, expressed in million tons (unweighted).

Q–hpf = Total quantity of high-protein feeds fed *minus* quantities of non-commercial milk, for the year beginning October, expressed in million tons (soybean meal equivalent).

Q–r = Q–t minus unweighted value of Q–hpf.

Q–s = Quantity of loans outstanding as of specified dates, plus purchase agreement grain delivered to CCC or placed under the loan program. For corn, the cutoff date is taken as May 31, and for oats, barley, and sorghum grains, March 31.

Q–fg = Q–r minus Q–s.

P–s = National average price support per bushel for corn, in cents.

P–c = Price per bushel received by farmers for corn, average for November to May, in cents.

P–hpf = Index numbers of wholesale prices of high-protein feeds (1935–39 = 100), average for November to May.

P–L = Index numbers of prices received by farmers for livestock and livestock products (1910–14 = 100), average for November to May.

AU = Number of grain-consuming animal units fed on farms during the year beginning October, in millions.

u_i = Random disturbances.

In this model, the variables Q–t, Q–r, Q–hpf, P–L, and AU are assumed to influence the endogenous variables P–hpf, P–c, and Q–s but not to be influenced by them to a significant extent during the period from November to May. Thus, they are treated as predetermined variables in this analysis. Strictly speaking, only the variable P–s can be so classified, but the amount of statistical error introduced by this simplifying assumption is believed to be small.

The variable Q–t includes the following components which are predetermined: (1) Production of the four feed grains, and (2) commercial stocks of the four feed grains It also includes: (1) Imports of grains for feeding during the year beginning October (such quantities are generally negligible); (2) domestic wheat and rye fed; (3) byproduct feeds fed; and (4) any decrease in stocks owned by the Commodity Credit Corporation from October 1 to May 31 for corn and March 31 for oats, barley and sorghum grains, or any decrease in old-crop loan stocks resealed. An important assumption of this analysis is that the stocks owned by the CCC as of May 31 for corn and March 31 for the other feed grains do not affect the November-May average price of corn, and so are deducted from the total supply as of October 1 (see King (*31*)).

The variable Q–hpf is the quantity of high-protein feeds fed during the October–September feeding year. As discussed on p. 2, these byproducts are utilized almost entirely for domestic feed use. To the extent that production of these items is predetermined, quantities fed are similarly predetermined. Possible exceptions to this are fish meal and copra meal, since imports are important for each of these feeds. Production of most of these feeds takes place during all the year, although it is heavier during the first and fourth quarters, for most feeds.[10] Estimates of the use for feed of the individual byproduct feeds are published annually in Grain and Feed Statistics (*55*) and in the Feed Situation (May and October issues) (*54*). Estimates for the oilseed meals, for example, are based on the Crop Reporting Board (*46*) production data on soybeans for beans, cottonseed, flaxseed, and peanuts picked and threshed, and on estimates of crushings for the season. To the extent that crushings of soybeans depend on the current price of soybean meal, it is not correct to assume that production of meal is predetermined. For the other oilseeds, however, the oil recovered in processing is the principal product in terms of value, and this also applies to soybeans in some years (see table 31). For other high-protein feeds, production depends only to a limited extent, if at all, on the current price of the byproduct feed.

The variable Q–r equals Q–t minus Q–hpf, and the comments on these two variables apply equally to this quantity.

The variable P–L may be considered mainly as predetermined, owing to lags in the marketing of livestock products. However, to the extent that producers of poultry and livestock products adjust the quantities coming onto the market depending on the current price of feeds, and thus influence the current price of livestock products, this assumption is not entirely correct. As indicated for hog feeding, producers tend to vary the market weight to some extent depending on the price of feeds purchased, the marginal productivity of these feeds, and the price of livestock products. Similar adjustments in feeding may be possible in the production of dairy products, fattening of beef cattle, and in the numbers of broilers raised. But a large proportion of the livestock and products sold during the November–May period are produced on feed from the previous crop of grains and from roughage, and would be sold during this period regardless of price. Some inventory adjustments are, of course, possible. In this model, as data are not deflated, the variable P–L serves to adjust for price level effects as well as to serve as an economic factor as such.

The variable AU has some of the limitations indicated for P–L, in that prices of feeds may influence, to some extent, the number of livestock fed during the October–September feeding year. This is more the case for poultry, such as broilers, which have a short production period, than for livestock, which require a longer time to attain market weight. It would be desirable to include inventory adjustments in a complete model.

Statistical Estimation of Current-Crop Grain Under Support

Factors that influence the quantity of current-crop grain under price support, as of a specified date, include several not easily specified such as the availability of storage and the amount of cooperation in the program. Farmers who are not eligible for the program, owing to

[10] Index numbers of seasonal variation in production are given in table 72.

non-compliance with acreage allotments, may tend to increase animal numbers and levels of feeding, and the aggregate quantity moving under support may be less than it would if all farmers were eligible for the loan. Although prices of livestock and livestock products and numbers of animals are, to some extent, determined simultaneously with the price of feed and the quantity going under support, for this formulation we assume they are given. This allows a least squares estimation of the quantity of current-crop grain placed under loan. The "degree of eligibility" is assumed to be reflected in livestock producers' reactions, that is, with changes in animal numbers; feeding rates are reflected to some extent in livestock prices. Under these conditions, the quantity of current-crop grain under support can be expressed as a function of the announced support level, supplies of feed concentrates not controlled by the government, prices of livestock products, and animal numbers.

The formulation is that given in equation (24). A statistical estimation of this relationship, based on an analysis for the years 1937–41 plus 1948, 1949, 1952 and 1953 is given below. Observations were transformed to logarithms, since a multiplicative relationship is assumed to hold among the several variables.

$$\text{Log } Q\text{-}s = -15.4 + \underset{(1.3)}{6.0} \log P\text{-}s + \underset{(6.4)}{17.8} \log Q\text{-}t - \underset{(2.1)}{9.7} \log P\text{-}L - \underset{(3.6)}{5.6} \log AU \qquad (24a)$$

The numbers in parentheses beneath the regression coefficients are their respective standard errors. The coefficient of determination was 0.95 and the standard error of estimate 0.115.

This function does not give a maximum limit to the quantity of current-crop grain under support, as was argued as plausible on theoretical grounds by the author (*31*). Nor did it seem reasonable to use a function that would allow for this, as only 9 years of data were available and certain important factors cannot be specified. The results from this equation are such that, with a given level of livestock prices and animal units, the estimated quantity of current-crop grain under loan increases at an increasing rate as the quantity of feed concentrates is increased. This implies that the quantity fed increases less, with a given decrease in price, than it would under the same demand conditions with no support program, (that is, the feeding curve is more inelastic under a support program at prices below the support price). When quantities of feed concentrates are very large in relation to livestock prices and animal units, the function implies that the demand curve for feeding actually turns back and becomes positively sloped. This, of course, is unrealistic; a method for estimating quantities of current-crop grain placed under support under these unusual conditions is given in the appendix (pp. 155–58).

Statistical Estimation of the Reduced-Form Equations

Equations (25) and (26) are the reduced-form equivalents of the demand relationships (22) and (23), respectively. Under the assumptions of the model, each of these reduced-form equations contains only one endogenous variable other than the variable Q–s, estimated from equation (24a). Estimates of the coefficients in these equations that are consistent, in a statistical sense, can be obtained if the equations are fitted directly by least squares, provided calculated values of Q–s are substituted for actual values before making the calculations. Systems of equations in which each equation can be fitted by least squares by the successive substitution of calculated values of endogenous variables are known as *recursive systems*, and the method of solving them is called the recursive approach. Although the estimates of the structural coefficients are statistically consistent, frequently they have larger standard errors than they would if they were estimated directly, as in the limited information approach. This method was used here because there appeared to be a need for adjustment in the estimated values of Q–s in certain years, based on the considerations previously noted.

In this model, the variables are assumed to be related in a multiplicative manner; that is, the effect of an increase in the price of protein feeds on the quantity fed varies in absolute amount depending on the level of the other variables in the analysis. A relationship of this kind was specified by converting the observations to logarithms. Statistical results from this specification give directly elasticities of demand which are constant throughout the range of the demand curve. Although the assumption of constant elasticity is considered as reasonable for the range of quantities fed included in the analysis, it is less satisfactory for very large or very small quantities fed. This is reflected, in part, by the data given on rates of substitution for hog feeding (see p. 69) which indicate that if supplies of high-protein feeds become relatively large in relation to feed grain supplies, the elasticity of demand more nearly approximates that of feed grains.

Data were transformed further to first differences of logarithms of the observations for two reasons: (1) An indication of serial correlation of the residuals of the reduced-form equations was found when the variables were expressed in logarithms (see table 45). A conversion to first differences has been found to correct for this in some analyses. (2) A variable may be needed to reflect the increased importance of protein feeds over the period analyzed. The use of first differences of logarithms provides a time factor in the constant term. A positive value implies a constant percentage increase over time. This is not as appropriate as the inclusion of a specific trend variable, but it seemed to be the only feasible solution in this instance.

Results from fitting equation (25) for high-protein feeds and equation (26) for feed grains are given below. This analysis included the years 1921–41 plus 1946–54, with observations transformed to first differences of logarithms.

$$\underset{}{P\text{–}hpf}=\underset{(.009)}{0.014}-\underset{(.39)}{0.93}\ Q\text{–}hpf-\underset{(.18)}{0.84}\ Q\text{–}fg+\underset{(.19)}{1.19}\ P\text{–}L+\underset{(.56)}{1.61}\ AU \qquad (25a)$$

$$P\text{–}c=\underset{(.010)}{0.014}-\underset{(.42)}{0.78}\ Q\text{–}hpf-\underset{(.19)}{2.06}\ Q\text{–}fg+\underset{(.20)}{1.52}\ P\text{–}L+\underset{(.61)}{2.43}\ AU \qquad (26a)$$

The numbers in parentheses beneath the regression coefficients are their respective standard errors. For equation (25a), the coefficient of determination was 0.81 and the standard error of estimate, 0.045. For equation (26a), the coefficient of determination was 0.92, and the standard error of estimate, 0.049.

Derived Estimates of the Demand Equations

The demand coefficients similarly are given for high-protein feeds [equation (22)] and for feed grains [equation (23)].

$$\text{Q–hpf}=0.014-\underset{(1.03)}{1.65}\ \text{P–hpf}-\underset{(.35)}{0.68}\ \text{P–c}+\underset{(.48)}{0.93}\ \text{P–L}+\underset{(.89)}{1.01}\ \text{AU} \quad (22a)$$

$$\text{Q–fg}=0.001+\underset{(.70)}{0.63}\ \text{P–hpf}-\underset{(.34)}{0.74}\ \text{P–c}+\underset{(.27)}{0.39}\ \text{P–L}+\underset{(.51)}{0.80}\ \text{AU} \quad (23a)$$

The coefficients in the demand equations are obtained by algebra from the reduced-form equations; the figures in parentheses are standard errors of the coefficients computed by a method suggested by Klein (*32*, pp. 258–259).

COMPARISON OF DEMAND ELASTICITIES FROM ALTERNATIVE FORMULATIONS

The statistical analyses given in the preceding section are those which are considered most reliable by the author. A number of alternative analyses were formulated to provide comparisons of results obtained for (1) different time periods, (2) logarithmic versus first difference of logarithmic transformations of observations, and (3) the price of an individual high-protein feed (cottonseed meal) versus the index of prices of high-protein feeds.

Changes Over Time

These analyses suggest that the demand for high-protein feeds for 1921–41 was less elastic than for 1921–41 plus 1946–54, although the two coefficients do not differ by a statistically significant amount. Analyses for 1946–54 tend to substantiate this finding of a greater degree of elasticity in later years, although the coefficients are not sufficiently reliable from a statistical standpoint to warrant publication. These results suggest the advisability of revision of these demand relationships as more years of data become available.

Comparison of the demand elasticities for the two time periods are given in the upper section of table 43. The reduced-form or price-flexibility equations, from which the demand coefficients were derived, are given in the lower part of table 43. In each case, observations were expressed as first differences of logarithms. Results for equations (25c) and (26c) differ slightly from those in equations (25a) and (26a), respectively, since in the c analyses actual values of the variable $Q\text{–}_s$ were used to obtain the quantity of feed grains, Q–fg, whereas in the recursive system, estimated values of $Q\text{–}_s$ were used. Although the differences are small, use of the estimated values of $Q\text{–}_s$ is preferable from the point of obtaining estimates of the demand coefficients that are statistically consistent. As indicated in table 43, the elasticity of

TABLE 43.—*High-protein feeds and feed grains: Demand elasticities and price flexibility coefficients obtained from analyses based on first differences of logarithms for alternative time periods* [1]

ELASTICITIES

Analysis	Quantity variable for feed	Elasticity with respect to— Price of— High-protein feed	Elasticity with respect to— Price of— Corn	Elasticity with respect to— Price of— Livestock and products	Elasticity with respect to— Animal units	Constant term
1921–41:						
(22b)	Q–hpf	−1.05	0.41	0.86	1.09	0.011
		(.58)	(.30)	(.33)	(.69)	
(23b)	Q–fg	.23	−.58	.50	.98	.013
		(.35)	(.18)	(.20)	(.42)	
1921–41 and 1946–54:						
(22c)	Q–hpf	−1.62	.67	.93	.99	.009
		(1.02)	(.60)	(.48)	(.90)	
(23c)	Q–fg	.59	−.72	.38	.86	.010
		(.70)	(.34)	(.27)	(.51)	

PRICE FLEXIBILITIES

Analysis	Price variable for feed	Price flexibility with respect to— Quantity of— High-protein feed	Price flexibility with respect to— Quantity of— Feed grains	Price flexibility with respect to— Price of livestock and products	Price flexibility with respect to— Animal units	Constant term	Coefficient of determination	Standard error of estimate
1921–41:								
(25b)	P–hpf	−1.14	−0.80	1.37	2.02	0.014	0.84	0.050
		(.47)	(.21)	(.24)	(.68)	(.011)		
(26b)	P–c	−.45	−2.05	1.41	2.49	.006	.92	.055
		(.53)	(.23)	(.26)	(.76)	(.013)		
1921–41 and 1946–54:								
(25c)	P–hpf	−.92	−.84	1.18	1.64	.014	.80	.046
		(.40)	(.18)	(.19)	(.58)	(.009)		
(26c)	P–c	−.75	−2.07	1.48	2.53	.014	.91	.052
		(.46)	(.21)	(.22)	(.66)	(.010)		

[1] Numbers in parentheses are the respective standard errors of the coefficients.

demand for high-protein feeds in 1921–41 is −1.05 as compared with −1.62 for 1921–41 plus 1946–54. An increase in the elasticity of demand for feed grains is noted also. Examination of the price flexibility coefficients in equations (26b) and (26c) for feed grains indicates that much of this increase in elasticity is due to a change in the coefficient associated with the quantity of high-protein feeds, since the price flexibility associated with the quantity of feed grains is about the same in each analysis.

A comparison between these time periods also was made with observations in logarithms, as shown in table 44. A similar increase in

TABLE 44.—*High-protein feeds and feed grains: Demand elasticities and price flexibility coefficients obtained from analyses based on logarithms for alternative time periods* [1]

ELASTICITIES

Analysis	Quantity variable for feed	Elasticity with respect to—			
		Price of—			Animal units
		High-protein feed	Corn	Livestock and products	
1921-41:					
(22d)	Q-hpf	−5.68	1.86	3.88	2.74
		(3.28)	(1.46)	(2.29)	(3.36)
(23d)	Q-fg	.49	−.63	.30	.75
		(.41)	(.18)	(.28)	(.42)
1921-41 and 1946-54:					
(22e)	Q-hpf	−9.66	2.89	6.96	3.81
		(6.62)	(2.55)	(4.19)	(4.96)
(23e)	Q-fg	.47	−.62	.34	.75
		(1.59)	(.19)	(.32)	(.38)

PRICE FLEXIBILITIES

Analysis	Price variable for feed	Price flexibility with respect to—				Constant term	Coefficient of determination	Standard error of estimate
		Quantity of—		Price of livestock and products	Animal units			
		High-protein feed	Feed grains					
1921-41:								
(25d)	P-hpf	−0.24	−0.70	1.13	1.18	−1.30	0.88	0.048
		(.10)	(.30)	(.10)	(.67)			
(26d)	P-c	−.18	−2.14	1.36	2.11	−1.12	.95	.042
		(.08)	(.26)	(.09)	(.59)			
1921-41 and 1946-54:								
(25e)	P-hpf	−.134	−.63	1.15	.99	−1.12	.95	.046
		(.067)	(.27)	(.08)	(.61)			
(26e)	P-c	−.10	−2.09	1.42	1.96	−1.06	.97	.044
		(.06)	(.26)	(.08)	(.58)			

[1] Numbers in parentheses are the respective standard errors of the coefficients.

the demand elasticity for protein feeds is suggested, whereas the demand elasticity for feed grains is more nearly the same in both periods. However, the coefficients obtained from the logarithmic analysis differ materially in magnitude from those given by the analyses based on first differences of logarithms. As noted previously, the first-difference transformation seemed desirable to allow for trends in the use of protein feeds. Results of the Durbin-Watson test for serial correlation in the four price flexibility equations in table 44 were inconclusive in three cases as to the presence of serial correlation (see table 45). We conclude that results obtained from the first-difference transformations are more valid, especially for the demand coefficients for high-protein feeds, than results from the logarithmic analyses.

TABLE 45.—*High-protein feeds and feed grains: Results of Durbin-Watson test of serial correlation for price flexibility analyses based on logarithms* [1]

Equation	Analysis values of—		Tabular values of—		Result [2]
	d'	$4-d'$	d_L	d_U	
(25d)	1.36	2.63	0.83	1.69	Inconclusive.
(26d)	1.74	2.26	.83	1.69	Reject.
(25e)	1.33	2.67	1.05	1.63	Inconclusive.
(26e)	1.53	2.47	1.05	1.63	Do.

[1] Tested at the 5-percent level of significance. For a description of the test, see Friedman and Foote (*15*, p. 77).

[2] Null hypothesis tested is that residuals are serially correlated. To reject this hypothesis, analysis values of d' and $4-d'$ must be greater than d_L. If neither d' or $4-d'$ is less than d_L, but one lies between d_L and d_U, the test is inconclusive. If both d' and $4-d'$ are greater than d_U, we assume that there is no serial correlation of residuals.

Use of the Price of a Single High-Protein Feed

Analyses were made, also, using the price of cottonseed meal for November–May rather than the index of prices of all high-protein feeds. This is similar to the use of the price of corn to represent the price of all feed grains, although it is less satisfactory. This fact is illustrated by subsequent analyses of the individual protein feeds. Results of this comparison are given in table 46. Implications for different time periods are similar to those from the analyses discussed previously. But, the indicated demand elasticity for high-protein feeds is about half that obtained by using the index of prices of high-protein feeds. This analysis is believed to reflect the less-elastic demand for cottonseed meal as compared with other protein feeds.

Additional evidence to support this assertion is provided by inspection of the price flexibility coefficients of various high-protein feeds, as shown in table 47. These data summarize results for price-generating equations for individual feeds presented in the next major section of this bulletin. For 1921–41, the cottonseed meal price

TABLE 46.—*High-protein feeds and feed grains: Demand elasticities and price flexibility coefficients obtained from analyses based on first differences of logarithms for alternative time periods when the price of cottonseed meal is used as representative of that for all high-protein feeds* [1]

ELASTICITIES

Analysis	Quantity variable for feed	Elasticity with respect to—				Constant term
		Price of—			Animal units	
		Cottonseed meal	Corn	Livestock and products		
1921–41:						
(22f)	Q–hpf	−0.58	0.32	0.54	1.01	0.013
(23f)	Q–fg	.13	−.56	.57	.99	.000
1921–41 and 1946–54:						
(22g)	Q–hpf	−.71	.39	.55	1.10	.014
		(.35)	(.03)	(.21)	(.60)	
(23g)	Q–fg	.26	−.62	.51	.82	.002
		(.24)	(.18)	(.15)	(.43)	

PRICE FLEXIBILITIES

Analysis	Price variable for feed	Price flexibility with respect to—				Constant term	Coefficient of determination	Standard error of estimate
		Quantity of—		Price of livestock and products	Animal units			
		High protein feed	Feed grains					
1921–41:								
(25f)	P–csm	−1.98	−1.14	1.72	3.13	0.025	0.77	0.079
		(.76)	(.33)	(.38)	(1.09)	(.18)		
(26b)	P–c	.45	−2.05	1.41	2.49	.006	.92	.055
		(.53)	(.23)	(.26)	(.76)	(.013)		
1921–41 and 1946–54:								
(26f)	P–csm	−1.83	−1.14	1.59	2.95	.028	.76	.068
		(.60)	(.28)	(.28)	(.87)	(.013)		
(26c)	P–c	−.75	−2.07	1.48	2.53	.014	.91	.052
		(.46)	(.21)	(.22)	(.66)	(.010)		

[1] Numbers in parentheses are the respective standard errors of the coefficients. The price of cottonseed meal used is the November–May average, wholesale per ton, bagged, at Memphis.

flexibility coefficient was −0.87 with respect to the quantity of cottonseed meal, which was larger than that for the other feeds for which analyses were made. In this connection, it should be noted that the price flexibility for total high-protein feeds in relation to total quantities of protein feeds fed reflects the direct- and cross-price flexibility coefficients for the various individual feeds. The weighted average of the direct- and cross-price flexibility coefficients is −1.18, compared with a price flexibility for total high-protein feeds using the index of prices of all protein feeds of −1.14. This comparison is imprecise since some feeds, such as fish meal and brewers' and distillers' dried grains, are not included in the analyses of individual feeds. Further, the manner in which a weighted average of flexibility coefficients are related to the total for all protein feeds is only known

TABLE 47.—*High-protein feeds: Comparison of price flexibility coefficients for individual feeds and that for the total from analyses based on first differences of logarithms for alternative time periods*

Time period and feed	Quantity weight [1]	Price flexibility with respect to—			
		Own quantity	Other high-protein feed	Total high-protein feed	Feed grains
Pre-World War II:					
Individual feed: [2]					
Cottonseed meal	46	−0. 87	−0. 63		−1. 22
Soybean meal	11	−. 58	−. 80		−. 88
Linseed meal	10	−. 55	−. 24		−. 94
Tankage and meat scraps	18	−. 62	. 05		−. 51
Gluten feed	15	−. 38	−. 64		−1. 13
Weighted average [3]				−1. 18	−1. 01
Total high-protein feeds index [4]				−1. 14	−. 80
Pre-World War II plus postwar:					
Individual feed: [2]					
Cottonseed meal	35	−. 54	−. 50		−1. 31
Soybean meal	32	−. 48	−. 18		−. 97
Linseed meal	8	−. 45	−. 13		−. 97
Tankage and meat scraps	13	−. 10	. 08		−. 53
Gluten feed	12	−. 38	−. 61		−1. 18
Weighted average [3]				−. 74	−1. 06
Total high-protein feeds index [4]				−. 92	−. 84

[1] Relative quantity fed during each period. Feeds listed accounted for about 85 percent of those included in the analysis for total high-protein feeds.

[2] These analyses are discussed in detail beginning on page 93. Postwar years included are 1946–54. Prewar years and the referral number for each equation are as follows: Cottonseed meal, 1921–41 and (29a); soybean meal, 1930–41 and (32a); linseed meal, 1921–41 and (33a); tankage and meat scraps, 1926–41 and (34a); gluten feed, 1926–41 and (35a). Referral numbers for the combined analyses are (29b), (32b), (33b), (34b), and (35b), respectively.

[3] Weighted average of the direct- and cross-price flexibility coefficients.

[4] Prewar years included are 1921–41 and postwar years are 1946–54. Referral numbers are (25b) for the prewar period and (25c) for the postwar years (see page 86).

in an approximate way, especially since the analyses for individual feeds do not all relate to the entire period from 1921. A similar relationship for 1921–41 plus 1946–54 indicates similar results, with a conclusion that the price flexibility for cottonseed tends to be larger than those for the other protein feeds. Normally the price flexibility coefficient for an individual feed tends to be somewhat less than for the total of all feeds, so that the individual demand elasticity is more elastic than that for the total of all feeds of a given classification. The increase in the price flexibility coefficient in 1921–41 and 1921–41 plus 1946–54 is due in part to the difference in composition of the protein feed aggregate. This is reflected in the weights shown in table 47.

COMPARISON OF DEMAND ELASTICITIES WITH RESULTS FROM OTHER STUDIES

A statistical analysis relating to the demand for total feed concentrates reported by Foote (*10*) indicates a price flexibility of −2.05 for the period 1921–41 with observations converted to logarithms, and a price flexibility of −2.36 with observations converted to first differences of logarithms. These analyses were estimated by least squares, and relate also to the November–May period for prices of corn and livestock and livestock products; total supplies of feed concentrates and animal units fed relate to the October–September feeding year. This study presents other analyses relating to various aspects of the feed-livestock economy. If the price flexibility coefficients in the logarithmic analyses (25d) and (26d) are weighted by the relative quantities of protein feeds and feed grains fed, the price flexibility for total concentrates is −2.28; if a similar computation is made for the price flexibility coefficients obtained with observations in first differences of logarithms in equations (25b) and (26b), the estimated price flexibility for total concentrates is −2.48. Differences between the respective coefficients obtained in our study and by Foote probably are not statistically significant. Also, in the Foote analyses, the price of corn was related to the quantity of total feed concentrates, and thus the weighting of the coefficients in the present study would not give an identical relationship.

Another statistical analysis of livestock production and marketing is that by Hildreth and Jarrett (*21*). Coefficients are estimated both by the limited information and least squares methods for various demand and supply relationships. Analyses relating to the demand for feed grains and for protein feeds are singled out for comparison, and the statistical results of the analyses by Hildreth and Jarrett are shown in table 48. For both the feed grain and protein feed equations, a complementary relationship between these feeds is indicated by the limited information fit, and a competitive relationship is suggested by the least squares fit. As pointed out by the authors, the coefficients upon which the cross-elasticities are based are not statistically significant. They conclude (*21*, p. 74) "Our a priori knowledge in this case is probably insufficient for us to regard either outcome as implausible." Their analyses relate to calendar year averages of prices for the period 1920–49. Quantity variables relate to amounts

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fed (expressed in terms of total digestible nutrients) of feed grains, protein feeds, and roughage. A total supply variable for feed grains was included in the complete system of equations. Prices of livestock and inventory of livestock on January 1 were additional variables in this analysis, which was run with observations expressed in logarithms.

TABLE 48.—*High-protein feeds and feed grains: Demand elasticities estimated by Hildreth and Jarrett from analyses based on logarithms for 1920–49* [1]

Quantity variable and method of estimation	Elasticity with respect to—				
	Price of—			Inventory of livestock on farms	Quantity of roughage fed to livestock
	Protein feeds	Feed grains	Livestock and products		
High-protein feeds fed:					
Limited information	−1.84	−0.69	1.81	1.19	−0.51
Least squares	−1.88	.23	1.39	.64	.16
Feed grains fed:					
Limited information	−.18	−.68	1.07	1.88	−.48
Least squares	.03	−.80	1.03	1.93	−.35

[1] See Hildreth and Jarrett (*21*, pp. 72–93). Results of the Durbin-Watson test at a percent level of significance allows the assumption of no serial correlation of residuals with the exception of the feed grains equation estimated by least squares, where the results were inconclusive.

Several differences between these and our analyses deserve special mention. The use of calendar year data was especially useful in their analysis of the demand for livestock products, but is considered less satisfactory for the demand for feed grains since this period overlaps two crop years. Further, the transformation of observations to first differences of logarithms in our analyses may tend to give cross-elasticities which are larger than those obtained with observations expressed in logarithms (for example, see tables 43 and 44). Automatic allowance for a time trend in the first-difference analysis is a possible explanation. The inclusion of the roughage fed variable is thought to have had little effect on the demand coefficients. The Hildreth-Jarrett protein feed equation, estimated by least squares, was rerun with this variable excluded, with little change in the demand coefficients for protein feeds and feed grains.

Conclusions reached from the present study and that of Hildreth and Jarrett indicate that the direct elasticity for high-protein feeds is approximately twice as elastic as that for feed grains. Their analysis gave a direct elasticity of −1.84 for protein feeds and −0.68 for feed grains; whereas equations (22a) and (23a) give a direct elasticity of −1.65 for high-protein feeds and −0.74 for feed grains. Results from the two studies are less in agreement as to the demand interrelationships between feed grains and high-protein feeds. For the least squares estimates of the Hildreth-Jarrett study, the elasticity of the quantity of protein feeds fed with respect to the price of feed grains is 0.23, compared with 0.68 as indicated by equation (22a). The elasticity of the quantity of feed grains fed with respect to the price of protein feeds is 0.03 as given by Hildreth and Jarrett, compared with 0.63 in equation (23a). Statements as to these demand interrelationships must be tentative since statistical coefficients vary considerably among the several analyses. This present study tends to indicate that these feeds have a strong competitive relationship, based on analyses with observations in first differences of logarithms, whereas the logarithmic relationships indicate a much weaker competitive relationship, more in line with the findings of the Hildreth-Jarrett study. Study of the aggregate of all high-protein feeds tends to average out the demand structure of the individual feeds. The following section attempts to isolate some of the special factors that influence prices of the most important byproduct feeds.

THE DEMAND FOR INDIVIDUAL BYPRODUCT FEEDS

Determination of demand coefficients for individual high-protein and other byproduct feeds is difficult, owing to the interrelationships with other feeds. The nature of this substitution in mixed feeds has been discussed previously. For certain of these feeds, regional conditions of supply and demand are especially important. In a given region, quantity of a given feed fed is related to (1) the price of that feed and prices of other protein feeds, other byproduct feeds, and feed grains, (2) prices of livestock and livestock products, and (3) the number of various types of livestock to be fed. With *n* such feeds, we have *n* equations expressing relationships of this sort. In terms of statistical analysis, however, regression coefficients for such a model cannot be estimated, mainly because of the lack of regional data, but even for the aggregate for the United States, some simplifying assumptions must be introduced.

Demand relationships are estimated for some of the principal byproduct feeds at principal markets. Before we consider the formulation of these models, we discuss regional differences in prices of certain feeds that are expected under various assumptions as to the kind of physical substitution possible among the feeds. Soybean meal and cottonseed meal are taken for this study, for they are the principal high-protein feeds. Similar reasoning can be applied to the other feeds.

REGIONAL DIFFERENCES IN PRICES OF SOYBEAN AND COTTONSEED MEAL

The market price of a particular feed in a given region depends upon such factors as: (1) Level of demand for protein supplements in that region as compared with other regions; (2) physical substitution rates among the various feeds; (3) available supply of feeds in the principal producing areas; (4) location of the region studied in relation to various producing areas; and (5) transportation costs of

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shipping the feed to various points. The determination of equilibrium regional prices for these feeds, assuming conditions of perfect competition, would require a complicated spatial equilibrium model which specified the various factors noted above. This was not attempted here because of the difficulty of separating out the demand functions for individual byproduct feeds, by regions, and of obtaining regional supply estimates.

The analysis in this section is concerned instead with price differences in selected major markets for given years and for changes over time. Consideration is given to physical substitution between soybean meal and cottonseed meal. Presented also is a theoretical model for the expected price differences among regions under certain restrictive assumptions. Actual price differences then are analyzed in the light of these theoretical considerations.

Production and net regional shipments of soybean meal and cottonseed meal are shown for the year beginning October 1949 (table 49). Production of soybean meal is concentrated in the Corn Belt region, though processing plants are located in most regions. Decatur, Illinois, commonly is considered the major market for soybean meal; this market is taken as a base for some of these price comparisons. Cottonseed meal production is located in the areas surrounding four principal markets—Memphis, Fort Worth, Los Angeles, and Atlanta. The Fort Worth market is taken as representative of production in the Southern Plains region, which normally accounts for about a third of the United States total. The Memphis market is taken as representative of production in the surrounding area (see figure 2, p. 41) including the States of Tennessee, Arkansas, and Mississippi.

TABLE 49.—*Soybean and cottonseed meal: Production and net shipments, by regions, year beginning October 1949* [1]

Region [2]	Soybean meal		Cottonseed meal	
	Production	Net regional shipments	Production	Net regional shipments
	Thousand tons	*Thousand tons*	*Thousand tons*	*Thousand tons*
Northeast	37	916	----------	97
Corn Belt	3,757	−1,787	45	272
Lake	200	184	----------	16
Northern Plains	136	107	----------	150
Appalachian	278	117	271	−60
Southeast	30	75	310	−31
Delta	125	−26	523	−275
Southern Plains	22	130	1,031	−301
Mountain	----------	74	105	226
Pacific	----------	210	213	−96

[1] Compiled from data, by States, presented by Jennings (*27*). Negative figures represent inshipments.

[2] Regional breakdown is that used by Fox (*18*) in his study of a spatial equilibrium model of the livestock-feed economy.

Production in these three States, which normally account for about a third of total production, amounted to 620 thousand tons in 1949–50. Net regional shipments from these three States amounted to 355 thousand tons for this year, or about half of the total shipped. The Los Angeles market is taken to represent California production, which has become relatively more important in recent years. In the discussion of market price differences to follow the Atlanta market is taken to represent production in Georgia and Alabama.

Substitution Between Soybean and Cottonseed Meal

Soybean and cottonseed meals are considered as substitutes in certain livestock rations, though allowance must be made for differences in specified nutritive values. Substitution applies particularly for feeding of ruminant, because they are not subject to certain toxic effects in cottonseed meal due to the gossypol content. In recent years processing techniques have been developed to remove these pigment glands, and some meal is sold as "low gossypol" meal. But cottonseed meal can be fed to hogs and poultry without adverse effects if it comprises a limited proportion of the ration. Practical limits for use in broiler feeds are discussed on page 61, and table 35 shows that these feeds differ in nutrient content. These meals also differ, by method of processing, as to protein and fat content. A comparison between the most commonly sold meals—soybean meal, solvent-process, 44 percent protein content, and cottonseed meal, expeller-process, 41 percent protein content—indicates the following differences: Soybean meal contains a higher crude and digestible protein content and a lower fiber content, whereas cottonseed meal contains a higher productive energy content. Other differences are noted in table 35, page 62.

The preference for one feed over the other in a formula feed, for example, depends, also, on the available supply of specified nutrients in other ingredients and the ingredient prices, as discussed previously (see p. 61). Since the substitution would vary by the nutrient specifications of various livestock rations, a complex equilibrium solution is indicated. Although it is difficult to determine the exact substitution between these meals, it is fairly clear that they are used interchangeably within certain limits. The pattern of regional prices for these two meals would be expected to depend directly on how these feeds are substituted by feeders and feed manufacturers in the various poultry and livestock rations.

The pattern of utilization of these meals, by kind of livestock, for the year beginning October 1949 is shown in table 50. This pattern of utilization to a large extent reflects the location of meal production in relation to the major type of livestock produced in that region, or in regions for which there is a transportation-cost advantage for that particular meal. Before discussing actual price differences for these meals in specified markets, we shall develop the pattern of prices that would be expected under certain restrictive conditions.

TABLE 50.—*Soybean and cottonseed meal: Percentage utilization for feed by type of livestock, year beginning October 1949*

Livestock group	Meal	
	Soybean	Cottonseed
	Percent	*Percent*
Poultry on farms	42	5
Hogs	29	5
Cattle:		
Dairy	20	36
Beef	2	51
Other	7	3
Total	100	100

From table 19.

Regional Prices and Trade for Homogeneous Feeds Under Conditions of Competitive Equilibrium

For an understanding of regional price differences, it is useful to consider a hypothetical regional pattern of production and demand, and to isolate the effects of changes in supply and transportation costs. Samuelson (*43*) presents a clear theoretical description of the determination of spatial price equilibrium under conditions of perfect competition, and the effects on prices and shipments with changes in regional supplies, or demand, and transportation costs. Also, he illustrates the application of linear programing techniques to the solution of such problems. Statistical application of spatial equilibrium models to problems in agriculture are given by Fox (*13*, *14*) for the livestock-feed economy, and by Judge (*30*) for eggs. As a complete model is not given here, it seems important to the discussion to present some of the basic considerations of spatial equilibrium theory as background for an examination of market price differences for these meals.

The problem confronting us is this: [11] We are given at each of two or more regions a demand and supply curve for a particular feed in terms of its market price at that locality. We also are given constant transportation costs for carrying one unit of the feed between any two of the specified localities. What then will be the final competitive equilibrium of prices in all the markets, the amounts supplied and demanded at each market, and the shipments among regions? In this development, we consider the feeds as homogeneous—that is, for practical purposes, we have only one feed—and that each is produced and demanded at two markets only.

Figure 6, section A, illustrates the two-market case under conditions of perfect competition for a good whose supply is not influenced by current price; the supply curve is inelastic for any given period. In

[11] This development follows the discussion given by Samuelson (*43*) and Judge (*30*).

Region I, the supply curve is indicated as S_1 and in Region II, as S_2. Given the market demand relationships D_1 and D_2, and with no trade between the two regions, the equilibrium price in Region I is P_1 and in Region II is P_2. These are the points where the supply and demand

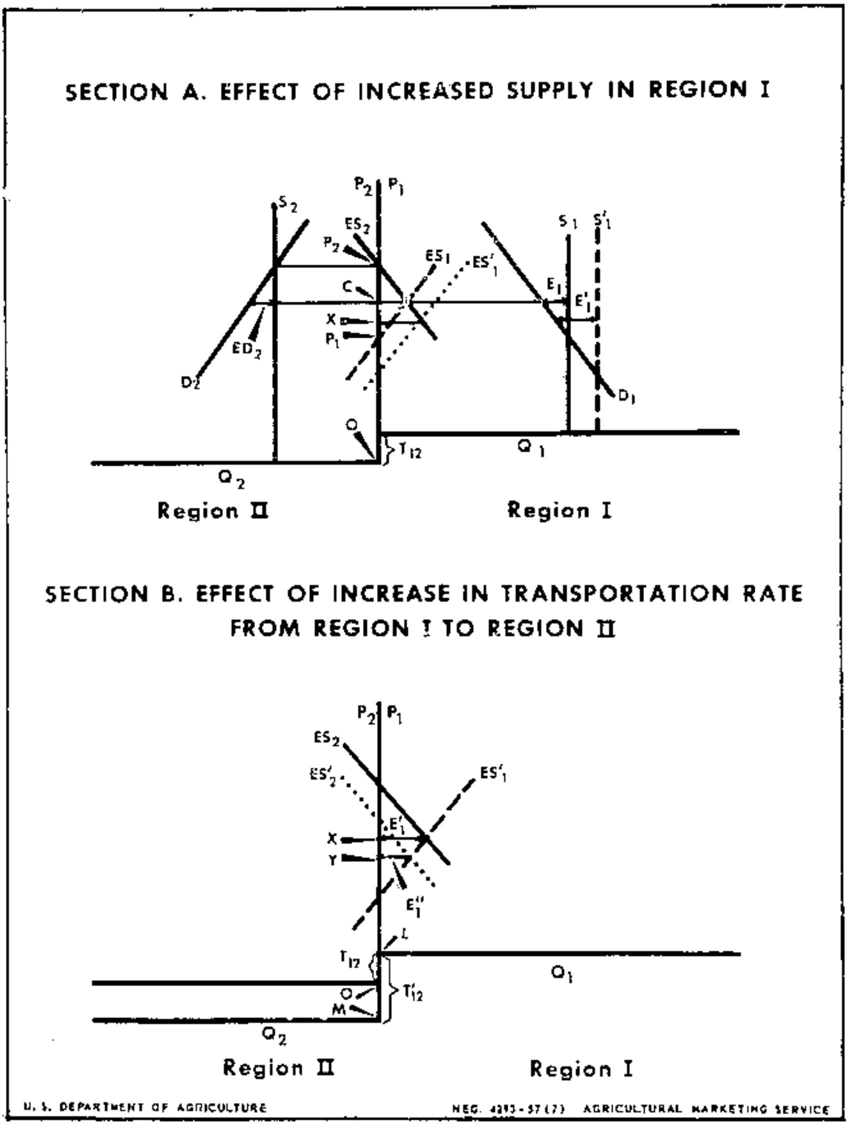

FIGURE 6.—The level of (1) equilibrium market prices and (2) shipments between regions depend upon the respective supply and demand conditions in the various markets and the transportation cost between markets. The effects on prices and shipments of an increase in the supply in one market are illustrated in Section A for a hypothetical 2-market case. The effects of a change in transportation costs are illustrated in Section B.

curves in each market just meet, or where the excess-supply functions ES_1 and ES_2—which equal the demand curve subtracted laterally at every price from the supply curve—are at their respective zero values.

Now assume that the feeds can move from Region I to II for T_{12} dollars per ton, and from II to I for T_{21} dollars per ton. Since the pre-trade price is lower in I than in II, trade flows only from I to II and T_{12} is the relevant transport cost. Since the initial difference in prices exceeds the transport cost, shipments are made from I to II; and P_2, at equilibrium, exceeds P_1 by the amount of T_{12}. For this reason the axes of Region I are displaced relative to those of Region II by the distance T_{12}. The new equilibrium price under interregional flows is established at OC where the excess-supply curve of Region I (ES_1) intersects the excess-supply curve of Region II (ES_2). Under these conditions, Region I ships quantity E_1 to Region II to fulfill the excess demand ED_2. The price in Region II equals the price in Region I plus the transportation cost, or

$$P_2 = P_1 + T_{12} \tag{27}$$

Effects of a shift in supply in Region II.—If shipments are made between these regions, an increase in supply in either market must have a downward effect on prices in both regions, and the decrease in the price in one market must exactly equal the price decrease in the second. In figure 6, section A, such an increase in supply is shown for Region I, with the shift in the supply curve from S_1 to S_1'. The excess-supply function shifts to the right and is indicated as ES_1', and the resulting new equilibrium price is now located at OX. The quantity of shipments is increased to amount E_1'.

Effects of an increase in transport cost.—In this 2-region case, an increase in transportation cost results in a decrease in shipments from Region I to Region II. The effects of this change are illustrated in figure 6, section B. Transportation costs are increased by an amount OM, which shifts the excess-supply curve for Region II downward from ES_2 to ES_2', and shipments are decreased from amount E_1' to E_1''. The market price in Region I is decreased from LX to LY; the price in Region II is increased from OX to MY; and the price difference between Region I and Region II is increased by amount OM, the transportation cost increase.

The multi-region case.—With more than two markets, considerations as to market equilibrium are more complex. Samuelson (*45*, p. 301) indicates these effects for shifts in the excess-supply function at one market as follows: "An increase in the excess-supply at (market) 1 must have a downward effect on every single price, or at worst leave it unchanged. The downward effect on other prices cannot exceed the downward effect on its own price; for all regions that stay continuously connected by direct or indirect trade with 1, the changes in P_1 must exactly equal the drop in P_1; but any regions that at any time remain disconnected from 1 . . . the change in P's will be less than the drop in P_1. And so long as we assume 'normal' positive sloping excess-supply curves everywhere, we can confidently assert that an increase of excess-supply in region 1 must decrease algebraic exports everywhere else, or at worst leave some of them unchanged."

Further, he points out (*43*, p. 302) that "a change in i's excess-supply function has exactly the same quantitative effect on E_j (that is, the shipments of region j) that a change in j's excess-supply function would have on E_i."

Also, as to the effect of an increase in transportation costs between i and j, he says (*43*, p. 299–300) "however other variables may change, exports from i to j must certainly decrease or at worst remain the same; such exports can certainly not increase."

Regional Prices for Nonhomogeneous Feeds Under Conditions of Competitive Equilibrium

The relationship among feed prices, by regions, for feeds which are not equal in feeding value, but differ only by a certain fixed percentage, can be specified readily. But for feeds which have certain characteristics that are more desirable for certain kinds of poultry or livestock, a more complex type of demand relationship is implied.

Feeds with a constant difference in feeding value.—If two feeds are used interchangeably, but differ only by some fixed amount, such as protein content, the equilibrium solution of prices and trade tends to be the same as that given for a homogeneous feed with one exception. The prices of the feeds differ by some fixed percentage, assuming that the feeds are purchased for protein content only.

Assume that feed 1 is produced exclusively in Region I and feed 2 is produced exclusively in Region II, and that the only difference between these feeds is that feed 1 has a protein content 90 percent of that of feed 2. The relationship between the prices of these feeds, if trade is assumed, is given as:

$$P_1 = 0.9P_2 + T_{12} \qquad (28)$$

Under equilibrium conditions, the solution is similar to that presented for the 2-region case discussed previously; this solution can be generalized for the case of multiregion producing and consuming areas.

Feeds with varying rates of substitution.—If the feeding value of a given feed varies with the amount included in the ration, the simple relationships noted in the preceding paragraphs do not hold. Further, if this rate of substitution varies by the type of livestock fed, additional regional demand factors have to be specified in the relationships. This more complex type of interrelationship is the one which holds among the various protein feeds, as indicated in the previous discussion of the composition of the feeds and the use by various kinds of livestock and poultry. But prices of soybean meal and cottonseed meal tend to indicate that these feeds are valued mainly for their protein content and are substituted in rations to a certain extent on the basis of a constant difference in protein content.

Implications as to expected price differences.—Several implications are obtained from the consideration of market equilibrium conditions which may aid in the comparison of market price differences. For any particular year, part of the price differences are random, reflecting at least partially, imperfections in the marketing system. But certain price differences occur consistently over time and are to be explained. We attempt to gain insight into the nature of the substitution between these meals by comparison of prices in various markets. It is recognized that use of specified markets to represent production and demand for a large surrounding area introduces error into the comparisons.

If the 2 feeds are 1-for-1 substitutes, we expect meal prices to be equal in markets connected by shipments. If the meals differ only by protein content and are purchased for nutritive content only, an added difference allows for this factor. Market price differences that deviate from this pattern reflect such factors as: (1) varying substitution rates for various kinds of livestock; (2) certain noncompetitive demands (see Armore *1*, p. 18), such as mentioned for formula feeds where there is a definite requirement for a certain amount of a given feed, but substitution can be made after this requirement is met; (3) restrictions as to the amount of a given feed which may be used for certain types of livestock; and (4) a market isolated from shipments from other regions.

Comparison of Cottonseed and Soybean Meal Prices at Specified Markets

The October–September average price of soybean meal tends to be higher than the price of cottonseed meal at certain markets, whereas the reverse is true in other markets. A comparison of market prices for these meals, given in table 51, indicates that the soybean meal price normally is higher in Memphis, Atlanta, Fort Worth, and San Francisco; whereas cottonseed meal prices sometimes are higher at Chicago, Boston, Cincinnati, and Kansas City. These prices refer to the most commonly sold meal. Differences in price for a given meal processed by the expeller or solvent method are discussed beginning on page 107.

Prices of these meals at Chicago indicate the variation in price differences for a centrally located market. For the year beginning October 1950, the price of cottonseed meal was $9.75 per ton higher than soybean meal; whereas for the year beginning October 1953, the price of soybean meal was $12.85 per ton higher than the price of cottonseed meal. Inspection of quantities of these two meals available for feeding indicate sharp changes from the respective previous years. In 1950, soybean meal supplies increased by 27 percent from the previous year, whereas cottonseed meal supplies dropped by 22 percent. In 1953, soybean meal supplies decreased by 10 percent from 1952, whereas cottonseed meal supplies increased by 8 percent from the previous year. This suggests that, for a given year, prices move independently to a certain extent. If the meals were considered as direct substitutes, prices would tend to be equal regardless of the quantity of each. Additional evidence of a certain independence in demand is obtained from the lack of consistent price differences of one meal over the other from one market to another.

The relationship between the price of cottonseed meal at Memphis with market prices in places that are major producing areas and with prices in places that are primarily consuming areas is given in table 52. A similar comparison is given for soybean meal, relating prices at specified markets with the Decatur price. Prices in these markets, over time, reflect varying conditions as to demand and supply and changing transportation costs. In the section on regional prices and trade under conditions of competitive equilibrium, we indicated the expected effect on prices of changes in supply (or demand) in the various regions or changes in transportation costs, if the markets are connected by shipments.

For cottonseed meal, price differences between Memphis and the consuming areas of Boston and Chicago show a trend over time that is closely related to general changes in railroad freight rates. The railroad freight rate for wheat is taken as a rough indicator of the general level of change over the period. This is less appropriate in areas where truck shipments are important.

The relationship between prices in two producing areas tends to be more complicated as shipments from these markets to consuming centers vary, depending on the demand for the feed in the several areas and the supply in a given year. Also, over time, shipments vary, depending on their transportation costs. In general, the price at Memphis is lower than in other producing areas. A more detailed comparison of market price differences between Memphis and Fort Worth is given in table 53. For the year beginning August 1949, the price of cottonseed meal at Fort Worth was slightly lower than the price at Memphis. These data reflect the influence of unusual supply changes on the market price difference. Texas production for the year beginning August 1949 was 60 percent above that for 1948; whereas Tennessee production in 1949 remained about constant, and the production in the three States of Arkansas, Mississippi, and Tennessee decreased by about 20 percent. Similarly, changes in the price difference during 1946–56 reflect the type of changes illustrated in figure 6, plus changes in the level of demand in the given region and in other regions to which shipments are made.

For soybean meal, a more specific comparison of market prices than that shown in table 52 is given in table 54 for November–May 1952–54. Specific rail freight rates for soybean meal shipped from Decatur to several markets are available, and these rates were constant for the calendar years 1953–55. It is recognized that railroad freight rates are not too appropriate for markets for which truck shipments are important, and this is a limitation. Market prices at Cincinnati are related closely to the price at Decatur plus freight charges, whereas at Memphis the price difference is much less than at Decatur plus freight. The location of processing plants in the various regions influence the points from which shipments are made to deficit areas, and the price differences between selected markets. The regional price structure for these meals cannot be explained by a simple comparison of the sort illustrated in table 54. A complete study would require quantification of the regional supply and demand curves and adequate data on transportation costs. The type of approach that should be used for supply aspects is illustrated by work on milk done by Bredo and Rojko (*6*). These aspects of the problem could then be incorporated into a model, such as that developed for the feed livestock economy by Fox (*18*), for which regional demand curves also are specified.

TABLE 51.—*Soybean and cottonseed meal: Comparison of average wholesale price per ton at 8 markets, average 1937–41, annual 1946–56* [1]

Year beginning October	Markets at which price of soybean meal tends to exceed that of cottonseed meal											
	Memphis			Atlanta			Fort Worth			San Francisco		
	Soybean meal	Cottonseed meal	Difference	Soybean meal	Cottonseed meal [2]	Difference	Soybean meal	Cottonseed meal	Difference	Soybean meal	Cottonseed meal	Difference
Average:	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1937–41	--------	27.45	--------	--------	30.95	--------	--------	33.40	--------	39.55	35.30	4.25
1946	--------	75.85	--------	82.85	77.50	5.35	86.60	80.45	6.15	89.70	84.80	4.90
1947	86.30	83.20	3.10	88.55	83.70	4.85	97.90	87.60	10.30	105.10	93.60	11.50
1948	71.35	63.10	8.25	70.80	62.85	7.95	82.25	66.50	15.75	91.40	71.75	19.65
1949	71.10	64.80	6.30	74.75	67.70	7.05	82.25	64.95	17.30	90.50	67.20	23.30
1950	72.20	76.90	−4.70	76.20	76.45	−.25	83.75	83.30	.45	93.90	75.65	18.25
1951	95.15	88.20	6.95	97.25	84.00	13.25	105.05	95.80	9.25	112.40	77.70	34.70
1952	76.70	71.95	4.75	77.90	74.15	3.75	87.65	79.50	8.15	97.35	82.50	14.85
1953	88.60	65.60	23.00	97.65	71.60	26.05	97.65	68.60	29.05	106.05	71.95	34.10
1954	67.90	64.25	3.65	77.65	68.10	9.55	79.00	69.70	9.30	87.90	73.45	14.45
1955	59.10	54.85	4.25	69.85	58.85	11.00	72.00	63.00	9.00	81.10	68.70	12.40
1956	54.55	55.20	−.65	64.15	60.45	3.70	67.45	61.30	6.15	77.00	67.30	9.70

	Markets at which price of cottonseed meal tends to exceed that of soybean meal											
	Chicago			Boston			Cincinnati			Kansas City		
Average:												
1937–41	31. 00	33. 50	−2. 50	--------	36. 80	--------	--------	33. 00	--------	32. 40	34. 15	−1. 75
1946	81. 10	--------	--------	85. 90	84. 70	0. 20	81. 45	82. 20	−0. 75	80. 35	82. 05	−1. 70
1947	91. 60	91. 95	−. 35	97. 45	96. 10	1. 35	91. 45	90. 85	. 60	90. 90	90. 75	. 15
1948	76. 40	72. 30	4. 10	83. 80	74. 85	8. 95	76. 55	71. 30	5. 25	75. 60	70. 00	5. 60
1949	74. 60	74. 10	. 50	81. 35	79. 95	1. 40	74. 10	73. 85	. 25	74. 00	70. 95	3. 05
1950	76. 90	86. 65	−9. 75	81. 85	90. 15	−8. 30	76. 45	86. 30	−9. 85	77. 25	85. 30	−8. 05
1951	96. 25	93. 45	2. 80	104. 60	97. 70	6. 90	93. 50	98. 70	−5. 20	97. 10	97. 30	−. 20
1952	80. 05	82. 50	−2. 45	86. 60	88. 20	−1. 60	79. 70	83. 50	−3. 80	79. 30	81. 25	−1. 95
1953	89. 80	76. 95	12. 85	97. 10	84. 85	12. 25	89. 75	78. 30	11. 45	88. 70	75. 70	13. 00
1954	71. 50	74. 40	−2. 90	79. 00	81. 50	−2. 45	71. 80	75. 20	−3. 40	70. 50	73. 30	−2. 80
1955	63. 50	65. 60	−2. 10	71. 65	72. 35	−. 70	63. 75	66. 30	−2. 55	63. 00	63. 95	−. 95
1956	58. 85	66. 80	−7. 95	66. 55	75. 00	−8. 45	59. 55	67 30	−7. 75	59. 10	65. 05	−5. 95

[1] Cottonseed meal: Bagged, 41 percent protein for all markets except San Francisco prior to October 1953 (43 percent); Kansas City prior to 1940 (43 percent); and Fort Worth prior to April 1947 (43 percent).

Soybean meal: Bagged, 41 percent protein prior to specified date for indicated markets: Memphis (July 1953); Atlanta (November 1953); San Francisco (July 1951); Chicago (July 1950); Boston (December 1951); Cincinnati (April 1951); and Kansas City (July 1950). Meal prices quoted for 44 percent protein for subsequent periods. Meal at Fort Worth, 41 and 44 percent protein. For all markets, quotation is for "mixes" for April to September, 1952.

[2] Quotation for Georgia mills, April 1949 to date.

TABLE 52.—*Cottonseed and soybean meal: Average wholesale price per ton in specified markets, difference in price between these markets and specified markets in producing and consuming areas, and index numbers of railroad freight rates, averages 1923–54* [1]

Year beginning October	Cottonseed meal							Index numbers of railroad freight rates [4]
	Memphis	Relation to Memphis						
		Producing areas			Consuming areas			
		Fort Worth	Atlanta [2]	Los Angeles	Chicago	Boston		
						Difference	Relative difference [3]	
Average:	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		
1923–26	36. 20	−2. 05			4. 85	8. 65	65	71
1927–31	32. 15	1. 00	[5] 0. 40		4. 80	8. 95	67	69
1932–36	25. 55	3. 80	2. 40	2. 80	5. 50	8. 80	66	68
1937–41	27. 45	5. 85	3. 50	. 35	6. 05	9. 35	70	69
1947–49	70. 35	2. 65	1. 05	3. 95	9. 10	13. 30	100	100
1950–54	73. 40	6. 00	1. 45	. 50	9. 40	15. 10	114	114

	Soybean meal							
	Decatur	Relation to Decatur for consuming areas						Index numbers of railroad freight rates [4]
		Kansas City	Minneapolis	Memphis	San Francisco	Buffalo		
						Difference	Relative difference [3]	
Average:								
1934–36	30.80	5.55	5.20	----------	[6] 7.60	5.80	56	68
1937–41	27.45	4.95	5.45	----------	12.10	6.00	57	69
1947–49	74.95	5.20	6.30	1.30	20.70	10.45	100	100
1950–54	76.40	6.15	7.35	3.70	23.10	11.10	106	114

[1] Cottonseed meal: Bagged, 41 percent protein for all markets and years except Fort Worth prior to April 1947 (43 percent protein), and Los Angeles, quoted as 40–43 percent meal.

Soybean meal: Bagged, 41 percent protein prior to specified date for the indicated market: Decatur, Kansas City, Minneapolis and Buffalo (July 1950); Memphis (July 1953); and San Francisco (July 1951). 44 percent meal for subsequent periods. For all markets, quotation is for "mixes" for April to September, 1952.

[2] Quotation for Georgia mills. April 1949 to date.

[3] Index numbers, 1947–49=100.

[4] Index numbers, 1948–50=100 that relate to wheat. Computed from data published in the *Marketing and Transportation Situation* (*50*) for recent years and by Reese (*42*) for prior years. Index numbers refer to the July–June year for 1923–41, and to calendar years for 1947 to date.

[5] Based on 1928–31.

[6] Based on 1935–36.

TABLE 53.—*Cottonseed meal: Average wholesale price per ton at Memphis and Fort Worth, and production in specified States, 1946–56*

Year beginning August	Price [1]			Production [2]		
	Memphis	Fort Worth	Difference	Arkansas, Mississippi, Tennessee	Tennessee	Texas
	Dollars	*Dollars*	*Dollars*	*Thousand tons*	*Thousand tons*	*Thousand tons*
1946	74.55	79.85	5.30	458	133	298
1947	86.80	90.90	4.10	578	148	569
1948	63.30	67.65	4.35	840	194	570
1949	63.20	62.50	−.70	654	193	911
1950	77.70	83.40	5.70	450	115	559
1951	83.85	91.55	7.70	607	161	723
1952	77.70	85.50	7.80	716	203	732
1953	64.70	66.90	2.20	856	222	815
1954	66.55	71.95	5.40	[3] 713	[3] 200	769
1955	---	---	---	---	---	---
1956	---	---	---	---	---	---

[1] Bagged, 41 percent protein. Computed from reports of the Grain Division, Agricultural Marketing Service.
[2] Production at oil mill locations, by States, as reported in *Animal and Vegetable Fats and Oils (59)*.
[3] Data estimated for some months.

TABLE 54.—*Soybean meal: Difference between wholesale price per ton at specified markets and at Decatur, and rail freight rates between Decatur and these markets, November–May, 1952–54*

Market	Price difference from Decatur for period beginning [1]—			Rail freight rate [2]
	1952	1953	1954	
	Dollars	*Dollars*	*Dollars*	*Dollars*
Cincinnati	6.58	6.95	6.76	6.78
Kansas City	6.15	4.94	4.79	8.62
Memphis	[3] 3.76	5.85	2.45	8.74
Minneapolis	6.56	4.62	4.56	9.44
Buffalo	10.83	10.66	10.66	11.96
Fort Worth	14.42	13.87	13.96	12.30

[1] Price quotations for bagged meal containing 44 percent protein. Computed from reports of the Grain Division, Agricultural Marketing Service.
[2] Based on interstate rates per 100 pounds, minimum weight 40,000 pounds. Data include the three percent Federal transportation tax, but exclude charges for protective services. Applies to calendar years 1943–55, during which rates were constant. Data do not allow for in-transit privileges.
[3] 41 percent protein.

DIFFERENCES IN PRICE DUE TO METHOD OF PROCESSING OILSEEDS

Currently, soybean meal is processed largely by the solvent-process, which yields a protein content of about 44 percent. This method replaced the screw press and hydraulic press methods, which accounted for more than half of the total soybeans processed until the year beginning October 1949. For the year beginning October 1946, solvent extraction accounted for 27 percent of the soybeans processed; for 1949, 56 percent; and for 1952, 86 percent. The price quotations, given in the previous section, were changed from 41 percent meal to 44 percent meal in July 1950 for several of the principal markets. At present, meal obtained by the solvent process from dehulled beans also is sold with a protein content of 50 percent.

The price of solvent and expeller soybean meal for the 1954 and 1955 seasons is given in table 55 for the Decatur market. Expeller meal prices averaged \$3.70 per ton higher than solvent meal for the year beginning October 1954, and \$5.15 higher for the year beginning October 1955. Although the solvent meal has a higher protein content, the productive energy and fat content is lower and the fiber content is slightly higher.

Cottonseed meal is processed mainly by the hydraulic and screw press methods, as noted on page 52, the solvent method accounting for 21 percent of the total processed in the year beginning August 1952. Meals from the different methods are sold with a guaranteed protein content of 41 percent. The expeller meal contains a higher productive energy and fat content, as shown in table 55. The average price of expeller meal at Memphis for the year beginning August 1954 averaged \$2 per ton higher than that for solvent meal, and \$1.80 higher for the year beginning August 1955.

Linseed meal processing for the year beginning July 1952 was mainly by the screw press method (54 percent), with prepress solvent extraction accounting for most of the remainder. (See table 29, p. 52). As indicated in table 55, the July–June average price for expeller linseed meal at Minneapolis averaged \$5.30 per ton higher than that for solvent meal for the 1954 July–June year, and \$5.65 higher for the 1955 July–June year. Expeller meal contains a higher fat and productive energy content, but a lower protein content.

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TABLE 55.—*Soybean, cottonseed, and linseed meal: Nutritive content and season average price, by type of processing, and range in monthly price differences between the expeller and solvent types, 1954 and 1955*

Item	Nutritive characteristic [1]			Season average price per ton [2]	
	Protein	Fat	Productive energy per pound	1954	1955
Soybean meal:	*Percent*	*Percent*	*Calories*	*Dollars*	*Dollars*
Expeller	42	3.5	640	64.40	57.70
Solvent	45	.5	570	60.70	52.55
Difference	−3	3.0	70	3.70	5.15
Range in monthly price differences:					
Low				2.40	2.20
High				6.40	7.00
Cottonseed meal:					
Expeller	41	4.0	690	66.55	54.80
Solvent	41	1.5	560	64.55	53.00
Difference	0	2.5	130	2.00	1.80
Range in monthly price differences:					
Low				1.10	−.50
High				2.75	2.85
Linseed meal:					
Expeller	32	3.5	500	71.25	65.20
Solvent	34	.5	480	65.95	59.55
Difference	−2	2.0	20	5.30	5.65
Range in monthly price differences:					
Low				3.80	4.10
High				8.00	7.00

[1] From 1956 Feedstuffs Analysis Table (22, p. 14).
[2] Price quotation for soybean meal (Decatur, bulk, unrestricted billing) for the October–September year; for cottonseed meal (Memphis, bagged) for the August–July year; and for linseed meal (Minneapolis, bagged) for the July–June year.

STATISTICAL ANALYSES THAT RELATE TO INDIVIDUAL BYPRODUCT FEEDS

An economic model that provides a framework for the analysis of the demand for individual high-protein feeds was formulated to permit the estimation of demand elasticities for individual feeds from reduced-form equations. Price-estimating equations relate to the November–May period, although the period is not entirely appropriate for all feeds. The general formulation of this model includes three reduced-form equations for each of the feeds to be analyzed. These are illustrated for cottonseed meal.

$$P_{csm} = a_1 + b_{11}Q_{csm} + b_{12}Q_{o-cm} + b_{13}Q_{fg} + b_{14}P_L + b_{15}AU + u_1 \quad (29)$$

$$P_o = a_2 + b_{21}Q_{csm} + b_{22}Q_{o-cm} + b_{23}Q_{fg} + b_{24}P_L + b_{25}AU + u_2 \quad (30)$$

$$P_{fg} = a_3 + b_{31}Q_{csm} + b_{32}Q_{o-cm} + b_{33}Q_{fg} + b_{34}P_L + b_{35}AU + u_3 \quad (31)$$

where P_{csm}=Price per ton at Memphis for cottonseed meal, bagged, average for November to May, in dollars.

P_o=Index numbers of wholesale prices for high-protein feeds, excluding cottonseed meal, average for November to May.

P_{fg}=Price per bushel received by farmers for corn, average for November to May, in cents.

Q_{csm}=Quantity of cottonseed meal fed during the year beginning October, in million tons.

Q_{o-cm}=Total quantity of high-protein feeds fed during the year beginning October, excluding (1) noncommercial milk and (2) cottonseed meal, in million tons of soybean meal equivalent.

Q_{fg}=Quantity of feed grains ($Q_r - Q_a$). See page 81 for definitions.

P_L=Index numbers of prices received by farmers for livestock and livestock products (1910–14=100), average for November to May.

AU=Number of grain-consuming animal units fed on farms during the year beginning October, in millions.

Utilization of the individual feeds differs by kind of livestock, and the argument might be made that different animal units and livestock prices should be used, depending on the protein feed being analyzed. This was not considered desirable for several reasons. If statistically significant coefficients are obtained from the model specified in equations (29)–(31), demand coefficients can be derived from these reduced-form equations by the method outlined previously for the demand for total high-protein feeds (see p. 85). Further, the demand for individual feeds having similar characteristics is related, even though the utilization by type of livestock may differ, due in part to location of production. Also, since an equation for the estimation of feed grain prices is included in the model, it is more reasonable to use data for total animal units and livestock prices.

Equations of type (29) were estimated first to determine whether the coefficients had a sufficient degree of statistical significance to warrant transformation of the price flexibility coefficients to demand elasticities. Although the direct price flexibilities were significant, in most cases, the cross-price flexibility coefficients for "other protein feeds" were not. Thus, none of the relations of the type specified in equations (30) and (31) were fitted. Although the results of these analyses are not satisfactory in terms of determining demand interrelationships among individual protein feeds, they are in agreement with *a priori* reasoning as to the expected relationship.

This analysis was formulated with the assumption that the effect of a change in the quantity of a given feed on its price depends on the level of supply of the other feeds. This implies that the quantity of cottonseed meal, other protein feeds, and feed grains exert a multiplicative effect on the price of cottonseed meal. This differs from the analysis for total high protein feeds, since in that analysis the protein feeds were aggregated into a single supply variable, weighted on the basis of protein content, thus implying that the feeds are direct substitutes if allowance is made for the difference in protein content.[12] There is some question as to the correct specification of this relationship; however, based on previous consideration of the demand relationships among these feeds, the formulation used appears reasonable.

Cottonseed Meal

The analysis of factors that affect the price of cottonseed meal parallels that for total high-protein feeds with the exception that the quantity variable is separated into cottonseed meal fed and other protein feeds fed. Also, the price of cottonseed meal is used rather than the index of prices of high-protein feeds. Results from the statistical fitting of equation (29) are given in table 56 for two time periods, and for analyses with observations expressed in logarithms and in first differences of logarithms. The use of the first-difference transformation gives cross-price flexibilities which are *relatively* more significant than for the logarithmic analyses, but the standard error of these coefficients in equations (29a) and (29b) each is larger than the value of the coefficient. The values of the direct-price flexibility coefficients, obtained by these two transformations, are about equal. Application of the Durbin-Watson test for serial correlation for the 1921–41 analysis with observations in logarithms indicates absence of serial correlation in the residuals; however, for the combined time period, the test is inconclusive. Thus, there is some preference for the first-difference analysis both from the view of possible serial correlation in the logarithmic analysis and the reliability of the values of the cross-price flexibility coefficients.

The direct-price flexibility for cottonseed meal, as indicated by analysis (29a), is −0.87 as compared with a value of −1.98 obtained in analysis (25f) (see p. 89) for which the price of cottonseed meal was related to the total quantity of high-protein feeds. The value of −1.98 includes both the direct- and cross-price flexibility effects. If the value of the cross-price flexibility coefficient in equation (29a) is added to the direct-price flexibility coefficient, a value of −1.50 is obtained. The difference between these values is due partly to the unreliability of the cross-price flexibility coefficient, but more importantly, to the difference between the additivity hypothesis of equation

[12] The additivity hypothesis as to the relationship among the high-protein feeds could have been tested statistically by using an adaptation of an iterative procedure presented by Foote (*10*, pp. 37–39).

TABLE 56.—*Cottonseed meal: Price-estimating equations that relate to the November-May average wholesale price, bagged, at Memphis*

Analysis	Coefficient with respect to—					Constant value	Coefficient of determination	Standard error of estimate
	Quantity of—			Price of livestock and products	Animal units			
	Cottonseed meal	Other high-protein feeds	Feed grains					
First difference of logarithms:								
1921–41 (29a):								
Coefficient	−0. 87	[1] −0. 63	−1. 22	1. 46	2. 59	[1] 0. 012	0. 77	0. 082
Standard error	(. 34)	(. 74)	(. 34)	(. 44)	(1. 22)	(. 019)		
1921–41 and 1946–54 (29b):								
Coefficient	−. 54	[1] −. 50	−1. 31	1. 23	2. 24	[1] . 011	. 74	. 073
Standard error	(. 22)	(. 60)	(. 29)	(. 34)	(1. 01)	(. 014)		
Logarithms: [2]								
1921–41 (29c):								
Coefficient	−. 76	[1] −. 03	−1. 12	1. 29	[3] 1. 55	−2. 08	. 89	. 059
Standard error	(. 18)	(. 10)	(. 37)	(. 13)	(. 84)			
1921–41 and 1946–54 (29d):								
Coefficient	−. 51	[1] −. 01	−1. 11	1. 30	1. 67	−2. 45	. 94	. 061
Standard error	(. 15)	(. 08)	(. 36)	(. 11)	(. 82)			

[1] Coefficient does not differ significantly from zero.
[2] The Durbin-Watson test rejects the null hypothesis that serial correlation in the residuals is present for equation (29d) and gives inconclusive results for equation (29c).
[3] Coefficient differs significantly from zero at the 5–10 percent probability level.

(25f) and the multiplicative hypothesis of equation (29a). It is clear, however, that the direct-price flexibility coefficient obtained by relating the price of a feed to its own quantity, holding the quantity of other substitute feeds constant, is lower than if related to the total quantity. Thus demand for an individual feed is more elastic than for the aggregate of total feeds.

Constant terms in the first difference analyses do not differ from zero by a statistically significant amount, suggesting no trend in the demand for cottonseed meal.

Soybean Meal

Formulation of the model used to estimate the demand relationships for soybean meal parallels that for cottonseed meal given in equation (29), with the obvious replacement of quantity and price variables. The price-estimating equation is as follows:

$$P\text{–}sbm = a_1 + b_{11} Q\text{–}sbm + b_{12} Q\text{–}o\text{–}sm + b_{13} Q\text{–}fg + b_{14}\ P\text{–}L + b_{15}\ AU \quad (32)$$

where P–sbm = Price per ton at Chicago for soybean meal, bagged, average for November to May, in dollars.

Q–sbm = Quantity of soybean meal fed during the year beginning October, in thousand tons.

Q–o–sm = Total quantity of high-protein feeds fed during the year beginning October, *minus* (1) noncommercial milk and (2) soybean meal, in million tons of soybean meal equivalent.

The period of analysis relates to the years 1930–41 and to the period 1930–41 plus 1946–54. A statistical analysis of the period 1946–54 did not give reasonable results and is not shown. As more years of data become available, it seems desirable to attempt further analyses of the demand for soybean meal, which is now the single most important protein feed. Results from the statistical fitting of equation (32) are given in table 57 for the two time periods and for analyses with observations expressed in logarithms and in first differences of logarithms.

In equations (32c) and (32d), for which variables were expressed in logarithms, the direct-price flexibility coefficients suggest a highly elastic demand. Also, the cross-price flexibility coefficients suggest a complementary demand between soybean meal and other high-protein feeds. These results do not appear reasonable. The upward trend in quantities fed was sharp during 1930–41 and again from this period to 1946–54, and probably a time variable should be included in this analysis. Further, results of the Durbin-Watson test are inconclusive as to the presence of serial correlation in the residuals of each equation.

Analysis of factors that affect the price of soybean meal using the first difference transformation of observations expressed in logarithms provides results more in line with *a priori* reasoning. The constant coefficients in analyses (32a) and (32b) each are statistically significant, suggesting a positive trend over time. The cross-price

TABLE 57.—*Soybean meal: Price-estimating equations that relate to the November-May average wholesale price, bagged, at Chicago*

Analysis	Coefficient with respect to—					Constant value	Coefficient of determination	Standard error of estimate
	Quantity of—			Price of livestock and products	Animal units			
	Soybean meal	Other high-protein feeds	Feed grains					
First difference of logarithms:								
1930–41 (32a):								
Coefficient	[1] −0.58	[2] −0.80	[3] −0.88	1.56	[2] 1.85	[1] 0.058	0.87	0.082
Standard error	(.23)	(.94)	(.45)	(.50)	(1.38)	(.026)		
1930–41 and 1946–54 (32b):								
Coefficient	−.48	[2] −.18	−.97	1.23	[3] 1.54	.033	.83	.063
Standard error	(.16)	(.48)	(.32)	(.29)	(.90)	(.015)		
Logarithms: [4]								
1930–41 (32c):								
Coefficient	[2] −.14	[2] .87	−1.39	[3] .66	[3] 1.96	−1.35	.80	.064
Standard error	(.10)	(.86)	(.50)	(.38)	(1.13)			
1930–41 and 1946–54 (32d):								
Coefficient	[1] −.17	[2] .48	[1] −.92	1.25	[3] 1.63	−2.51	.94	.064
Standard error	(.08)	(.41)	(.45)	(.16)	(1.01)			

[1] Coefficient differs significantly from zero at the 5–10 percent probability level.
[2] Coefficient does not differ significantly from zero.
[3] Coefficient differs significantly from zero at the 10–20 percent probability level.
[4] The Durbin-Watson test for serial correlation of the residuals gave inconclusive results for both equations.

flexibility coefficients do not differ significantly from zero; this also was true in the analysis of cottonseed meal. However, the coefficients have the expected negative sign, indicating a substitution relation between soybean meal and other protein feeds (mainly cottonseed meal).

More years of data are required before reasonable estimates of the current demand elasticities for soybean meal can be obtained from statistical analyses.

Linseed Meal

The model used to analyze the demand relationships for linseed meal parallels that given for cottonseed meal on page 109. The price-estimating equation for linseed meal was fitted first to determine whether it was feasible to attempt fitting the second and third equations in the reduced-form set. The equation is as follows:

$$P\text{-}lsm = a_1 + b_{11}Q\text{-}lsm + b_{12}Q\text{-}o\text{-}lm + b_{13}Q\text{-}fg + b_{14}P\text{-}L + b_{15}AU + u_1 \quad (33)$$

where P–lsm = Price per ton at Minneapolis for linseed meal, bagged, average for November to May, in dollars.

Q-lsm = Quantity of linseed meal fed during the year beginning October, in thousand tons.

Q–o–lm = Total quantity of high-protein feeds fed during the year beginning October, *minus* (1) noncommercial milk and (2) linseed meal, in million tons of soybean meal equivalent.

The periods of analysis relates to the years 1921–41 and 1921–41 plus 1946–54. Results of these analyses are given in table 58 for equations fitted to observations transformed to first differences of logarithms. The constant value, which reflects trend over time, is not significant in either equation. The level of the direct-price flexibility coefficients approximate that for soybean meal, and similarly, the cross-price flexibility coefficients do not differ from zero by a statistically significant amount.

Statistical time series analysis of the three principal oilseed meals do not provide a sound basis for determining the demand interrelationships among these feeds. Appraisal of various price and quantity data indicates that the price variation from year to year depends principally on the quantity of the particular feed in question. However, the general level of prices tends to reflect the influence of similar factors for all feeds. These effects vary from region to region depending on the relevant supply and demand conditions, as discussed on pp. 93–100 in connection with relationships between prices of cottonseed and soybean meals.

Comparisons of the price of linseed meal at Minneapolis and at Chicago and Buffalo, given in table 59, indicate the magnitude of year-to-year fluctuations in price differences between various markets. Although the bulk of the linseed processing is done in Minnesota, some is processed in Illinois and New York. In all years prices are

TABLE 58.—*Linseed meal: Price-estimating equations that relate to the November-May average wholesale price, bagged, at Minneapolis when the variables are converted to first differences of logarithms*

Analysis	Coefficient with respect to—					Constant value	Coefficient of determination	Standard error of estimate
	Quantity of—			Price of livestock and products	Animal units			
	Linseed meal	Other high-protein feeds	Feed grains					
First difference of logarithms:								
1921–41 (33a):								
Coefficient	−0. 55	[1] −0. 24	−0. 94	1. 45	1. 99	[1] 0. 004	0. 77	0. 062
Standard error	(. 13)	(. 57)	(. 26)	(. 31)	(. 88)	(. 014)		
1921–41 and 1946–54 (33b):								
Coefficient	−. 45	[1] −. 13	−. 97	1. 08	[2] 1. 24	[1] . 007	. 6J	. 060
Standard error	(. 11)	(. 50)	(. 25)	(. 26)	(. 77)	(. 012)		

[1] Coefficient does not differ significantly from zero.
[2] Coefficient differs significantly from zero at the 10–20 percent probability level.

TABLE 59.—*Wholesale price per ton: Relationships among prices of linseed meal at Minneapolis, Chicago, and Buffalo and among prices of linseed, soybean and cottonseed meals at Chicago, averages 1925–29, annual 1946–56*

Year beginning October	Price of linseed meal				Percentage that price of linseed meal is of price of specified meal, Chicago [4]	
	Actual		Difference between specified market and Minneapolis			
	Minneapolis [1]	Chicago [2]	Buffalo [3]	Chicago	Soybean	Cottonseed
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Percent*	*Percent*
Average:						
1925–29	48.95	50.35	0.30	1.40	--------	119
1930–34	30.40	30.90	.85	.50	104	112
1935–39	35.65	37.80	.70	2.15	125	118
1946	81.55	85.10	6.15	3.55	105	91
1947	81.25	85.85	4.25	4.60	94	93
1948	67.25	71.90	5.35	4.65	94	99
1949	69.30	74.00	3.50	4.70	99	100
1950	64.20	69.15	7.45	4.95	90	80
1951	76.70	80.35	3.85	3.65	83	86
1952	73.25	79.05	9.20	5.80	99	96
1953	69.95	75.00	5.90	5.05	84	97
1954	65.25	70.05	5.90	4.80	98	94
1955	58.85	63.90	8.25	5.05	101	97
1956	56.10	61.55	10.05	5.45	105	92

[1] 34 percent protein, October 1925–March 1933, December 1936–August 1937, May 1947–June 1950, August 1954–December 1954; 37 percent, April 1933–November 1936, September 1937–September 1939; and 36 percent, July 1950–July 1954, January 1955–September 1956.

[2] 34 percent protein, October 1925–April 1935, July 1948–June 1950, November 1950–August 1951, and February 1954–September 1956; 32 percent, May 1935–August 1935, March 1937–October 1938, May 1939–November 1939, October 1946–June 1948, September 1951–May 1953; 37 percent, October 1935–February 1937, October 1937–March 1939, September 1939–August 1941, December 1953–January 1954.

[3] 32 percent protein, October 1946–April 1947; 34 percent, May 1947–June 1950, August 1954–November 1954; 36 percent, July 1950–July 1954, December 1954–September 1956.

[4] Protein content of soybean and cottonseed meal is shown in table 51.

higher in Chicago and Buffalo than in Minneapolis, but the price spread varies widely from year to year.

Complications in the analysis of linseed meal prices are (1) the difference in protein content from one season to another and (2) changes due to the method of processing. The latter applies also to soybean and cottonseed meals. Despite these limitations, it is useful to compare prices of the three meals at the Chicago market, as shown in table 59. The price of linseed meal averaged 104 percent of the price of soybean meal during 1930–34; 125 percent for 1935–39; and 95 percent for 1946–55. As linseed meal has 82 percent of the protein content of soybean meal, the relative prices indicate that this is not the only factor considered by purchasers. As noted previously, linseed meal is a desired feed, especially for cattle, due to its slightly laxative effect and other characteristics. Substitution between these feeds can be studied more accurately by an analysis of the substitution of ingredients in the broiler feed specified on page 62, although, for linseed meal, feed ingredients for dairy cattle rations would be more appropriate.

Copra Meal

No statistical time series analyses were attempted to determine the demand for copra meal. This item is utilized mainly on the West Coast and would require a regional analysis. A comparison of the price of copra meal with cottonseed meal at the Los Angeles market is shown in table 60. Copra meal is quoted at 20 percent protein as compared with 41–43 percent for cottonseed meal. However, prices of copra meal have averaged higher than cottonseed meal in recent years.

TABLE 60.—*Los Angeles: Wholesale price per ton of copra and cottonseed meal, averages 1932–39, annual 1946–56*

Year beginning October	Actual price for—		Price of copra meal as a percentage of price of cottonseed meal
	Copra meal [1]	Cottonseed meal [2]	
	Dollars	*Dollars*	*Percent*
Average:			
1932–34	21.20	26.75	79
1935–39	26.65	29.00	92
1946	70.85	81.05	87
1947	85.35	90.50	94
1948	67.35	68.05	99
1949	64.05	64.35	99
1950	64.65	75.80	85
1951	90.05	82.15	110
1952	82.55	74.30	111
1953	67.70	67.75	100
1954	70.80	69.40	102
1955	68.60	62.70	109
1956	66.65	63.65	105

[1] Bagged, 20 percent protein.
[2] Bagged, 40–43 percent protein for 1932–39, and 40 percent for 1946–56.

Peanut Meal

The price of peanut meal at southeastern milling points has tended to be about 90 percent of the price of soybean meal and about 101 percent of the price of cottonseed meal for 1946–55. The fluctuations from year to year in the relative prices of these meals are indicated in table 61. Exports of peanut meal, for 1946–55, have been important in relation to available supplies, as noted in table 7, page 14. A statistical analysis of the demand for peanut meal was not attempted since it accounts for a relatively small proportion of total high-protein supplies, and it is difficult to specify an export equation. As in the case of copra, regional demand conditions would have to be specified to obtain an accurate reflection of the demand for this feed.

TABLE 61.—*Southeastern milling points: Wholesale price per ton for peanut, cottonseed, and soybean meals, averages 1925–39, annual 1946–56*

Year beginning October	Season average price [1]			Price of peanut meal as a percentage of the price of—	
	Peanut meal	Cottonseed meal	Soybean meal	Cottonseed meal	Soybean meal
	Dollars	*Dollars*	*Dollars*	*Percent*	*Percent*
Average:					
1925–29	42.85				
1930–34	24.10	24.15		100	
1935–39	27.25	28.65		95	
1946	74.10	77.50	82.85	96	89
1947	83.20	83.70	88.55	99	94
1948	65.50	62.85	70.80	104	93
1949	68.30	67.70	74.75	101	91
1950	68.35	76.45	76.20	89	90
1951	90.85	84.00	97.25	108	93
1952	76.40	74.15		103	
1953	79.05	71.60	97.65	110	81
1954	73.80	68.10	77.65	108	95
1955	55.75	58.85	69.85	95	80
1956	50.20	60.45	64.15	83	78

[1] Bagged quotations as follows: Peanut meal, 45 percent protein, cottonseed meal, 41 percent protein, Atlanta through March 1949, and Georgia mills for subsequent period; and soybean meal, 41 percent protein through 1951–52, and 44 percent, 1953 to date, southeastern milling points.

Meat Scraps and Tankage

Year-to-year changes in the price of meat scraps are closely associated with changes in the price of tankage. For 1931–41, 93 percent of this variation was associated with the price of tankage, and 96 percent for 1946–53. The price of digester tankage at Chicago averaged 105 percent of the price of meat scraps for 1946–55, as shown in table 62. These price quotations refer to 50 percent protein content for meat scraps and to a high-grade tankage which contains a protein content higher than that for meat scraps.

Data on production of these feeds has been reported separately since July 1944. Due to the close association of the prices of these products and to their similar characteristics, an analysis of the demand for these products was formulated expressing the price of tankage as a function of the combined quantity of the two products and other relevant variables. The form of this equation is as follows:

$$P\text{-}t = a_1 + b_{11}Q\text{-}_{t+ms} + b_{12}Q\text{-}_{o}\text{-}_{t+ms} + b_{13}Q\text{-}fg + b_{14}P\text{-}L + b_{15}AU + u_1 \quad (34)$$

where P–t=Price per ton at Chicago for tankage, average for November to May, in dollars.

Q–t+ms=Quantity of tankage and meat scraps fed during the year beginning October, in thousand tons.

Q–o—t+ms=Total quantity of high-protein feeds fed during the year beginning October, *minus* (1) noncommercial milk and (2) meat scraps and tankage, in million tons of soybean meal equivalent.

TABLE 62.—*Tankage and meat scraps: Wholesale price per ton at Chicago, averages 1925–39, annual 1946–56*

Year beginning October	Actual price		Price of tankage as a percentage of price of meat scraps
	Tankage, digester	Meat scraps (50 percent protein)	
Average:	*Dollars*	*Dollars*	*Percent*
1925–29	67.40		
1930–34	35.15		
1935–39	50.40	49.20	102
1946	110.65	101.80	109
1947	119.40	110.30	108
1948	120.65	116.55	104
1949	118.05	113.05	104
1950	118.55	114.15	104
1951	115.55	113.25	102
1952	93.70	91.00	103
1953	106.70	102.45	104
1954	84.70	79.10	107
1955	73.75	71.80	103
1956	77.70	73.10	106

Results from this formulation did not warrant the estimation of the other reduced-form equations. The statistical estimation of the above relationships was for the periods 1926–41 and for 1926–41 plus 1946–54, with observations transformed to first differences of logarithms. Results given in table 63 agree with expectations based on economic theory. Meat scraps are used in rations such as broiler feeds to supply part of the so-called fish factor. In the period of the analysis, these feeds were valued also for the so-called "animal protein factor," a term which has since fallen into disuse due to the isolation of vitamin B–12 (see p. 65). Also, prior to the synthetic production of methionine, these feeds were an important source of this amino acid.

The cross-price flexibility coefficient indicates a complementary demand relationship with other protein feeds; however, this coefficient does not differ from zero by a statistically significant amount and no definite conclusions may be drawn from the results. The result is not unreasonable, since if there is a fixed requirement in certain manufactured feeds for this quantity of animal protein, a complementary

TABLE 63.—*Tankage: Price estimating equations that relate to the November–May average wholesale price at Chicago when the variables are converted to first differences of logarithms*

Analysis	Coefficient with respect to—					Constant value	Coefficient of determination	Standard error of estimate
	Quantity of—			Price of livestock and products	Animal units			
	Tankage and meat scraps	Other high-protein feeds	Feed grains					
First difference of logarithms:								
1926–41 (34a):								
Coefficient	[1]−0. 62	[1]0. 05	−0. 51	1. 25	2. 36	[1]0. 002	0. 88	0. 047
Standard error	(. 72)	(. 45)	(. 22)	(. 24)	(. 98)	(. 012)		
1926–41 and 1946–54 (34b):								
Coefficient	[1]−. 10	[1]. 08	−. 53	1. 08	1. 51	[1]. 005	. 81	. 045
Standard error	(. 42)	(. 36)	(. 20)	(. 19)	(. 66)	(. 009)		

[1] Coefficient does not differ significantly from zero.

relationship is implied. The coefficient with respect to feed grains indicates that a given change in the supply of these grains has less effect on the price of tankage and meat scraps than on the price of oilseed meals.

Fish Meal

A study by regions would be necessary to quantify the demand for fish meal. Data are not readily available for this analysis. Imports of meal are an important source of quantities fed, which would add further complications. Prices of fish meal for the Atlantic and Pacific Coasts are compared with prices of meat scraps and soybean meal in table 64. The quotation for Buffalo refers to menhaden meal, 60 percent protein content, f. o. b. seaboard, whereas the prices for meat scraps and soybean meal relate to prices at Buffalo. Thus, an additional transportation charge should be added to the fish meal price for direct comparability.

The price of fish meal expressed as a percentage of meat scraps has averaged higher since 1946 than during 1935–39. Since the "fish factor" of broiler nutrition is supposedly present in meat scraps as well as in fish meal and fish solubles, it is not possible to attribute the change in the relative prices to this factor alone. A more detailed analysis of the demand for fish meal is required to isolate factors influencing the changes shown in relative prices. Fish meal in relation to soybean meal indicates a change in the price relatives in the same direction but of less magnitude.

Gluten Feed and Meal

The price of gluten meal at Chicago averaged 138 percent of the price of gluten feed for 1946–54, whereas the protein content of gluten meal is about 165 percent of that for gluten feed. The price comparisons, shown in table 65, relate the price of gluten meal to soybean meal, since these feeds have a similar protein content. For the 1946–55 period, gluten meal averaged 98 percent of the price of soybean meal. A comparison between gluten feed prices and prices of middlings indicates that for 1946–55, gluten feed prices averaged 102 percent of the price of middlings which has a slightly lower protein content. These comparisons indicate considerable year to year variation in price ratios, however.

Production and sales data refer to the total of these two feeds. An attempt was made to determine if there is a difference in the price flexibility coefficients for these feeds. The price of gluten meal and the price of gluten feed were related to the total quantity of the meal and feed and the same other variables. Results of these analyses were inconclusive. Regional analyses would have been more appropriate, but adequate data were not available. Further, small variations in production of minor feeds in general do not exert a measurable effect on the level of prices determined in the feed-livestock economy.

TABLE 64.—*Buffalo and San Francisco: Wholesale price per ton for fish meal, meat scraps, and soybean meal, average 1935–39, annual 1946–56*

Year beginning October	Buffalo [1]			Price of fish meal as a percentage of—		San Francisco [2]			Price of fish meal as a percentage of—	
	Fish meal	Meat scraps	Soybean meal	Meat scraps	Soybean meal	Fish meal	Meat scraps	Soybean meal	Meat scraps	Soybean meal
	Dollars	*Dollars*	*Dollars*	*Percent*	*Percent*	*Dollars*	*Dollars*	*Dollars*	*Percent*	*Percent*
Average: 1935–39	51. 02	50. 45	32. 69	101	156	43. 43	38. 76	36. 89	112	118
1946	125. 30	112. 50	84. 10	111	149	159. 50	98. 40	89. 70	162	178
1947	137. 50	117. 05	95. 81	117	144	163. 20	110. 95	105. 10	147	155
1948	170. 80	134. 20	80. 75	127	212	193. 45	122. 45	91. 40	158	212
1949	151. 15	120. 40	79. 60	126	190	156. 20	104. 95	90. 50	149	173
1950	131. 45	120. 05	81. 20	109	162	148. 90	95. 90	93. 90	155	159
1951	137. 85	125. 50	103. 15	110	134	160. 75	111. 20	112. 40	145	143
1952	135. 30	97. 10	83. 95	139	161	160. 25	93. 00	97. 35	172	165
1953	134. 15	107. 26	93. 80	125	143	150. 70	101. 82	106. 05	148	142
1954	139. 35	78. 88	75. 45	177	185	162. 70	91. 15	87. 90	178	185
1955	140. 00	75. 35	67. 90	186	206	156. 10	81. 80	81. 10	191	192
1956	133. 75	74. 10	63. 95	180	209	149. 50	79. 50	77. 00	188	194

[1] Bagged quotations as follows: Fish meal, menhaden, 60 percent protein, f. o. b. seaboard; meat scraps, 50 percent protein and soybean meal, 41 percent protein, 1935–39 and 1946–49, and 44 percent for subsequent years.

[2] Bagged quotations as follows: Fish meal, sardine, 67 percent protein; meat scraps, 55 percent protein, 1935–39 and 1946–53, and 50 percent for subsequent years; and soybean meal, 41 percent protein, 1935–39 and 1946–49, and 44 percent for subsequent years.

The model used is as follows:

$$P\text{-}gf = a_1 + b_{11}Q\text{-}_{g(f\&m)} + b_{12}Q\text{-}_{o-g(f\&m)} + b_{13}Q\text{-}fg + b_{14}P\text{-}L + b_{15}AU + u_1 \quad (35)$$

$$P\text{-}gf = a_1 + b_{11}Q\text{-}_{g(f\&m)} + b_{12}Q\text{-}_{o-g(f\&m)} + b_{13}Q\text{-}fg + b_{14}P\text{-}L + b_{15}AU + u_1 \quad (36)$$

where P–gf = Price per ton at Chicago for gluten feed, bagged, average for November to May, in dollars.

P–gm = Price per ton at Chicago for gluten meal, bagged, average for November to May, in dollars.

Q–g(f&m) = Gluten feed and meal sales during the year beginning October, in thousand tons.

Q–o–g(f&m) = Total quantity of high-protein feeds fed during the year beginning October, *minus* (1) noncommercial milk, and (2) gluten feed and meal, in million tons of soybean meal equivalent.

TABLE 65.—*Chicago: Wholesale prices per ton for corn gluten meal and feed, and selected averages 1930–39, annual 1946–56* [1]

Year beginning October	Actual price		Price of gluten meal as a percentage of soybean meal	Actual price		Price of gluten feed as a percentage of middlings
	Gluten meal	Soybean meal		Gluten feed	Middlings (standard spring wheat)	
Average:	*Dollars*	*Dollars*	*Percent*	*Dollars*	*Dollars*	*Percent*
1930–34	26.03	29.59	88	20.03	17.70	113
1935–39	30.72	30.37	101	23.70	24.25	98
1946	73.70	81.10	91	58.30	58.50	100
1947	88.45	91.60	97	74.45	71.90	104
1948	74.85	76.40	98	53.80	52.70	102
1949	77.10	74.60	103	51.90	51.50	101
1950	79.55	76.90	103	52.05	58.65	89
1951	85.45	96.25	89	63.55	65.70	97
1952	82.35	80.05	103	60.10	55.35	109
1953	82.35	89.80	92	55.55	50.70	110
1954	67.73	71.50	95	50.60	47.75	106
1955	67.25	63.50	106	46.00	45.00	102
1956	69.15	58.85	118	45.50	43.70	104

[1] Bagged quotations. Gluten meal generally contains about 41 percent protein; soybean meal quotations are for 41 percent protein for 1930–49, and 44 percent for subsequent years. Gluten feed generally contains about 21 percent protein, and standard spring wheat middlings, about 15 percent.

The results from the statistical estimation of the above relationships for 1926–41 and for 1926–41 plus 1946–54 are given in table 66. Observations were transformed to first differences of logarithms.

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TABLE 66.—*Gluten feed and meal: Price estimating equations that relate to the November–May average wholesale price at Chicago when all variables are converted to first differences of logarithms*

Analysis	Coefficient with respect to—					Constant value	Coefficient of determination	Standard error of estimate
	Quantity of—			Price of livestock and products	Animal units			
	Gluten feed and meal	Other high-protein feeds	Feed grains					
Gluten feed:								
1926–41 (35a):								
Coefficient	[1]−0.38	[1]−0.64	−1.13	1.44	[1]2.06	[1]0.011	0.77	0.09
Standard error	(.69)	(.89)	(.46)	(.51)	(1.80)	(.024)		
1926–41 and 1946–54 (35b):								
Coefficient	[1]−.38	[1]−.61	−1.18	1.23	[1]1.51	[1].013	.74	.078
Standard error	(.40)	(.66)	(.37)	(.35)	(1.22)	(.017)		
Gluten meal:								
1926–41 (36a):								
Coefficient	[1].14	[2]−1.03	−.95	1.29	[3]2.20	.009	.84	.06
Standard error	(.45)	(.58)	(.30)	(.33)	(1.17)			
1926–41 and 1946–54 (36b):								
Coefficient	[1].02	[2]−.69	−.99	1.09	[3]1.80	.001	.78	.054
Standard error	(.28)	(.46)	(.26)	(.24)	(.85)			

[1] Coefficient does not differ significantly from zero.
[2] Coefficient differs significantly from zero at the 10–20 percent probability level.
[3] Coefficient differs significantly from zero at the 5–10 percent probability level.

Values of direct-price flexibility coefficients do not differ from zero by a statistically significant amount. The same is true for the cross-price flexibility with respect to the quantity of other high-protein feeds. Relationships for gluten feed are more satisfactory, with the expected sign obtained for all coefficients. The results for gluten meal are included only as an indication of possible limitations to this approach. Gluten meal accounts for about one-fourth of the total production of these products, and prices tend to correspond to soybean meal and other comparable high-protein feed prices, as indicated in table 65.

Brewers' and Distillers' Dried Grains

It did not appear feasible to determine demand elasticity coefficients for these feeds, since they account for a small proportion of the total fed. Brewers' dried grains contain about 25 percent protein as compared with about 28 percent for corn distillers' dried grains. Distillers' dried grains are sold as "light" (without solubles) and "dark" (with solubles). The "dark" grains prices, as indicated in table 67, are slightly higher than for the "light" grains. The distillers' dried solubles are higher in price and valued for the content of B-complex vitamins and as a possible source of the "whey factor" desired for broiler rations (see p. 65).

Prices of brewers' dried grains and distillers' dried grains at Buffalo and Cincinnati are indicated in table 68 for the years beginning October 1935-39 and 1946–56. At Buffalo, the price of brewers' dried grains averaged 85 percent of the price of distillers' dried grains for 1946–55, as compared with 79 percent for 1935–39. At Cincinnati, a similar comparison indicates an average relative price of 89 percent for 1946–55, and 84 percent for 1935–39. The protein content of brewers' dried grains is about 89 percent of that of distillers' dried grains, but other feed characteristics probably are important in determining their relative feeding value (see table 35, p. 62). Prices of brewers' dried grains at Buffalo averaged 70 percent of soybean meal prices for 1946–55, and 74 percent of soybean meal prices at Cincinnati.

TABLE 67.—*Distillers' dried grains, "light" and "dark", and distillers' dried solubles: Average wholesale price per ton at Buffalo, 1953–56*

Year beginning October	Distillers' dried grains			Distillers' dried solubles
	Light (without solubles)	Dark (with solubles)	Difference	
	Dollars	*Dollars*	*Dollars*	*Dollars*
1953	70.55	72.45	1.90	88.00
1954	68.45	69.65	1.20	85.35
1955	62.00	63.30	1.30	82.00
1956	61.75	63.30	1.55	95.90

TABLE 68.—*Buffalo and Cincinnati: Wholesale price per ton of brewers' and distillers' dried grains as compared with price of soybean meal, average 1935–39, annual 1946–56.*

Year beginning October	Buffalo				Cincinnati			
	Actual price		Price of brewers' dried grains as a percentage of—		Brewers' dried grains [1]	Distillers' dried grains [4]	Price of brewers' dried grains as a percentage of—	
	Brewers' dried grains [1]	Distillers' dried grains [2]	Distillers' [2]	Soybean meal [3]			Distillers'	Soybean meal [5]
Average:	*Dollars*	*Dollars*	*Percent*	*Percent*	*Dollars*	*Dollars*	*Percent*	*Percent*
1935–39	23.90	30.25	79	73	23.80	28.20	84	------
1946	58.05	67.70	86	69	59.00	64.40	92	72
1947	72.75	83.30	87	76	69.65	79.90	87	76
1948	57.45	71.00	81	71	56.30	68.30	82	74
1949	54.00	64.75	83	68	54.15	63.35	85	73
1950	54.60	61.20	89	67	55.70	59.40	94	73
1951	65.95	72.30	91	64	65.30	68.30	96	70
1952	61.70	75.05	82	73	59.95	73.20	82	75
1953	58.85	70.55	83	63	60.30	67.40	89	67
1954	55.50	68.45	81	74	55.20	63.80	87	77
1955	51.90	62.00	84	76	52.50	56.00	94	82
1956	52.95	61.75	86	83	55.15	57.95	95	93

[1] Bagged.
[2] Bagged, in carlots. Designated as "light" beginning March 1948. (See table 67 for price of "dark" grains.)
[3] Bagged, 41 percent protein, 1935–39 and 1946–49; and 44 percent for subsequent years.
[4] Bagged. Beginning January 1952 classified as "light" and beginning July 1954 described as "corn".
[5] Bagged, 41 percent protein prior to April 1951, and 44 percent for subsequent years.

Wheat Millfeeds

Data on production of wheat millfeeds, by class of wheat, are not published, and the statistical estimation of demand relationships applies to the total quantity fed in the United States. A major market for spring wheat millfeeds is at Minneapolis. Production of this type of wheat is centered in the Northern Great Plains. For purposes of price comparisons, Kansas City, Missouri, is taken as representative of the hard red winter wheat millfeeds. This type wheat is grown principally in the Central and Southern Great Plains. Soft red winter wheat is produced in many East North Central and Southern States, white wheat production is located in the Pacific Northwest and also in Michigan, New York, and California, and durum wheat is produced principally in North Dakota. A study of the demand for wheat by Meinken *(35)* provides a detailed analysis of factors that affect the utilization of wheat among milling, exports, and fed as such.

Principal milling centers, include Kansas, New York, Minnesota, Missouri, and Illinois.

Wheat millfeeds from hard spring wheat generally contain a slightly higher content of protein, fat, and total digestible nutrient than comparable millfeeds from hard winter wheat, as indicated in feed composition tables presented by Morrison (*37*, pp. 1129–1130). Although regional conditions are not fully accounted for, the data presented in table 69 indicate that the price of bran from spring wheat at Minneapolis averages slightly higher than from winter wheat at Kansas City. The price of bran at Minneapolis for 1946–55 averaged about 95 percent of the price of standard middlings, a feed which has a lower fiber and higher total digestible nutrient content.

TABLE 69.—*Wheat millfeeds: Average wholesale price per ton for spring wheat millfeeds at Minneapolis and for winter wheat millfeeds at Kansas City, averages 1920–39, annual 1946–56*

Year beginning October	From spring wheat, Minneapolis			From winter wheat, Kansas City		
	Bran	Standard middlings	Bran relative to middlings	Bran	Grey shorts	Bran relative to grey shorts
	Dollars	*Dollars*	*Percent*	*Dollars*	*Dollars*	*Percent*
Average:						
1920–24	22.20	23.10	96	22.40		
1925–29	26.10	27.15	96	25.65	30.45	84
1930–34	15.45	15.80	98	14.65	17.65	83
1935–39	20.45	21.85	94	19.45	23.20	84
1946	51.30	55.70	92	49.95	56.50	88
1947	62.10	68.30	91	59.95	69.65	86
1948	47.55	49.05	97	45.00	49.75	90
1949	45.50	48.10	95	42.70	48.90	87
1950	52.00	54.95	95	49.70	56.10	89
1951	59.80	61.55	97	58.60	63.55	92
1952	50.10	50.90	98	49.60	53.00	94
1953	45.15	46.80	96	43.00	47.95	90
1954	41.10	43.00	96	39.15	45.70	86
1955	39.65	41.10	96	37.60	41.60	90
1956	39.25	39.60	99	37.45	39.35	95

Grey shorts are winter wheat millfeeds which contain about the same nutritive content as standard middlings. The price of these millfeeds at Kansas City was consistently higher than for standard middlings at Minneapolis, as shown in table 69. The price of bran at Kansas City averaged about 89 percent of the price of grey shorts for 1946–55, and about 84 percent for 1925–39.

Prices of the principal wheat millfeeds normally move in the same direction from year to year. For 1921–41, 98 percent of the year-to-year variation in the price of bran at Minneapolis was associated with changes in the price of standard middlings, and for 1946–53, 99 percent of this variation was so related. A statistical analysis of the price of standard spring wheat middlings was run for 1926–41 and for 1926–41 plus 1946–54. Observations were expressed in first

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TABLE 70.—*Wheat millfeeds: Price-estimating equations that relate to the November-May average wholesale price of standard spring wheat middlings at Minneapolis when all variables are converted to first differences of logarithms*

Analysis	Coefficient with respect to—					Constant value	Coefficient of determination	Standard error of estimate
	Quantity of—			Price of livestock and products	Animal units			
	Wheat-millfeeds	High-protein feeds	Feed grains					
First difference of logarithms:								
1926–41 (37a):								
Coefficient	−2.58	[1] −0.65	−1.78	1.77	3.55	[1] 0.006	0.92	0.065
Standard error	(.94)	(.71)	(.29)	(.35)	(1.03)	(.017)		
1926–41 and 1946–54 (37b):								
Coefficient	[2] −1.31	[3] −1.08	−1.71	1.68	3.33	[1] .010	.87	.063
Standard error	(.66)	(.60)	(.27)	(.30)	(.91)	(.013)		

[1] Coefficient does not differ significantly from zero.
[2] Coefficient differs significantly from zero at the 5–10 percent probability level.
[3] Coefficient differs significantly from zero at the 10–20 percent probability level.

differences of logarithms. The price-estimating equation is of the following form:

$$P\text{–}m = a_1 + b_{11}Q\text{–}mf + b_{12}Q\text{–}hpf + b_{13}Q\text{–}mg + b_{14}P\text{–}L + b_{15}AU + u_1 \qquad (37)$$

where P–m = Price per ton at Minneapolis for standard middlings, bagged, average for November to May, in dollars.

Q–mf = Wheat millfeeds fed during the year beginning October, in million tons.

Q–hpf = Total quantity of high-protein feeds fed during the year beginning October, minus noncommercial milk fed, in million tons.

Q–mg = Q–fg (see p. 81 for definition) minus Q–mf, in million tons.

The results of these analyses, shown in table 70, indicate considerable change in the direct-price-flexibility coefficient when the years 1946–54 are included in the analysis. A separate analysis for 1946–54 indicates a reduction in the direct-price flexibility for wheat millfeeds, although the results do not warrant publication. These results tend to indicate that wheat millfeeds have a demand structure approximating more nearly that of feed grains than of some of the high-protein feeds.

SEASONAL VARIATION IN PRICES, PRODUCTION, AND DISAPPEARANCE

Index numbers of seasonal variation were computed uniformly for the post-World War II period 1947–54. Because of a sharp change in the seasonal pattern in prices for soybean meal, index numbers also were computed for 1930–42 for this item. These index numbers were obtained by the method developed by the Bureau of the Census for use on their electronic computer, and the computations were made by them. This method provides a check on whether the seasonal pattern is changing over time, but the index numbers shown in all cases represent an average for the periods indicated. No significant changes in patterns within periods were found.

Data on prices are given in table 71 and on production and disappearance or related variables, in table 72. Disappearance figures are obtained by adding production, imports, and stocks at the start of the month and subtracting exports and stocks at the end of the month. Unfortunately, data on stocks are lacking for important positions other than at processing plants, so that the disappearance data in part represent accumulations or reductions in stocks in unreported positions. Thus the seasonal pattern indicated for disappearance does not necessarily represent the seasonal pattern in actual consumption. No data on stocks are available for the following feeds: Meat scraps, tankage, fish meal, gluten feed and meal, and wheat millfeeds.

TABLE 71.—*Byproduct feeds: Index numbers of seasonal variation in average wholesale prices, selected markets, average 1947–54* [1]

Feed and market	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Oilseed meal:												
Soybean, Chicago:												
1930–42	104	99	97	98	98	*95*	100	102	*104*	98	101	104
1947–56	98	95	96	100	101	104	*108*	106	101	*95*	97	99
Cottonseed, Memphis	103	98	98	99	98	98	103	104	*96*	97	101	*105*
Linseed, Minneapolis	*111*	103	100	101	97	*92*	95	96	97	99	102	107
Peanut, Southeast	103	100	99	99	98	99	*104*	103	100	*96*	98	101
Copra, Los Angeles	102	102	99	98	100	101	*103*	100	98	*96*	101	100
Tankage, Chicago	*106*	101	99	96	93	*93*	97	101	103	104	102	105
Meat scraps, Chicago	103	100	99	98	*95*	96	101	*104*	103	101	99	101
Fish meal, Eastern	105	*105*	104	104	99	95	*94*	96	96	99	100	103
Dried grains:												
Brewers', Milwaukee	*113*	110	104	100	96	*90*	90	91	93	98	104	111
Distillers', Cincinnati	*104*	101	101	101	102	99	98	97	*97*	98	100	102
Gluten—												
Meal, Chicago	102	100	99	101	100	101	103	*103*	100	96	*96*	99
Feed, Chicago	104	*105*	103	102	103	99	100	98	97	*94*	95	100
Alfalfa meal, Kansas City:												
Sun-cured	*106*	102	96	96	97	*92*	94	98	102	105	106	106
Dehydrated	*119*	119	108	105	84	*76*	82	87	94	107	108	111
Wheat millfeeds, Minneapolis:												
Bran	105	98	109	*114*	109	94	96	92	92	*91*	97	103
Middlings	100	94	106	110	*111*	108	102	92	94	*91*	93	99
Molasses, blackstrap:												
New York	106	100	97	103	97	96	*95*	98	99	100	102	*107*
Beet pulp (with molasses), San Francisco	103	*107*	106	104	100	98	98	97	*96*	96	96	99
Groups of feeds:												
High-protein feeds	101	98	99	100	100	100	*105*	103	99	*96*	98	101
Oilseed meals	101	97	98	99	100	101	*106*	104	99	*96*	98	101
Animal and fish byproducts	*103*	100	99	99	*97*	97	102	103	101	100	98	101
Grain byproducts	*105*	104	102	101	102	98	98	98	97	*96*	97	102

[1] Unless otherwise specified. Numbers in italics represent respective seasonal highs and lows based on unrounded data.

TABLE 72.—*Byproduct feeds: Index numbers of seasonal variation in production and disappearance, United States, average 1947–54* [1]

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Oilseed meals:												
Soybean:												
Production	*116*	105	109	102	101	90	91	86	*74*	103	111	112
Disappearance	110	98	103	98	101	93	93	93	*82*	109	*110*	110
Cottonseed:												
Production	146	115	97	69	51	37	*31*	44	114	*177*	171	148
Disappearance	138	113	102	73	52	*43*	45	53	102	164	*167*	148
Linseed:												
Production	99	91	93	83	*82*	97	102	106	116	*119*	109	103
Disappearance	112	93	98	84	77	*74*	84	113	112	*123*	112	118
Peanut:												
Production	*123*	120	115	118	122	111	83	62	*49*	72	108	117
Disappearance	111	113	105	110	*129*	105	96	86	*64*	77	102	102
Copra:												
Production	108	88	104	104	95	95	*78*	105	102	*115*	102	104
Disappearance	99	90	95	97	101	99	*89*	96	101	109	109	*115*
Production:												
Tankage	113	103	95	*88*	90	91	91	99	94	103	116	*117*
Meat scraps	103	93	*98*	98	101	101	98	101	99	*103*	103	102
Fish meal:												
Production [2]	27	*14*	15	30	70	181	*229*	213	165	129	67	60
Disappearance [3]	49	*35*	56	56	88	167	*187*	167	137	119	68	71
Sales of gluten feed and meal [3]	99	*92*	103	99	100	97	94	98	101	*110*	104	103
Production:												
Dried grains:												
Brewers'	88	*82*	98	98	106	118	*120*	118	103	98	84	87
Distillers'	114	119	*128*	110	100	88	*72*	74	87	100	96	112
Wheat millfeeds	108	95	98	*91*	92	94	99	103	104	*112*	102	102
Alfalfa meal:												
Sun-cured	*123*	98	90	76	*71*	94	109	105	96	107	114	117
Dehydrated	*8*	12	26	47	137	*232*	231	197	159	107	31	13

[1] Numbers in italics represent respective seasonal highs and lows based on unrounded data.
[2] Principal meals.
[3] Data on stocks not available.

OILSEED MEALS

Prices of oilseed meals tend to drop markedly at the start of the new crushing season. Index numbers of seasonal variation in market prices of oilseed meals and other byproduct feeds are shown in table 71. For soybean meal, prices in recent years have decreased on the average from an index of 101 in September to 95 for October. Production of soybean meal for these same months increased from an index of 74 to 103, as shown in table 72. Disappearance data show a similar increase at the beginning of the new crushing season, although this undoubtedly reflects, at least in part, some stock accumulations in unreported positions. Index numbers of seasonal prices vary from a low of 95 in October to a high in July of 108, or a range of 13 points. There is less seasonal variation in soybean meal prices than in certain byproduct feeds with more marked seasonal patterns of production (for example, dehydrated alfalfa meal), but somewhat more variation than in those with little seasonal variation in production (for example, meat scraps). Prices during October–March tend to be low relative to those in April–September, whereas computed disappearance tends to be high during the first period and low in the second. There is some reason to believe that price variation is associated in part, with available supplies of the meal, though other factors, such as seasonal requirements for protein supplements, exert important influences on the pattern of prices by months. Also, some variation in crushings occur during the season, depending on the price of oilseeds and oil and meal.

Seasonal variation in production of cottonseed meal is considerably greater than in that of soybean meal; it ranges from a low of 31 in July to a high of 177 in October. Index numbers of cottonseed meal prices drop sharply from August to September, the start of the new crushing season. The index numbers of prices vary from a low of 96 in September to a high of 105 in December, or a range of only 9 points. Production of meal is heavy from September to February relative to the low production in May through August. Cottonseed meal is used to a large extent for winter feeding of beef cattle, and prices tend to be relatively high during December and January. Prices also tend to rise towards the end of the marketing season, reflecting, in part, the limited availability of cottonseed meal.

The crushing season for linseed meal generally is regarded as the July–June year. Production of linseed meal is less seasonal than for cottonseed meal but, as indicated in table 72, it has tended to reach a seasonal low in May and to increase to a high in October. Index numbers of prices of linseed meal at Minneapolis drop from May to a seasonal low in June, and then increase to a seasonal high in January. Disappearance data tend to be high from September to February relative to the March–July period. As for cottonseed meal, prices tend to reflect seasonal requirements for the meal in addition to some effects from variations in seasonal supplies.

The crushing season for peanut meal varies by region of production. For the United States, peanut meal production reaches a low in September and a seasonal high in January, as shown in table 72. Prices of peanut meal at Southeastern mills show a seasonal low of 96 in October, a month for which production of meal for the United

States shows a marked increase from the previous month. Prices of peanut meal tend to rise seasonally through January, to decrease through the Spring, and then to reach a seasonal high of 104 in July; however, the range in price index numbers was only 9 points.

Copra meal prices exhibit a similar pattern.

OTHER BYPRODUCT FEEDS

Animal and Fish Byproducts

Index numbers of seasonal variation in the price of tankage at Chicago range from a low of 93 in June to a high of 106 in January, as shown in table 71. Prices tend to be relatively high from September through January, a period for which production is relatively high also, as shown in table 72.

Production of meat scraps show somewhat less seasonal variation than does tankage, and prices of meat scraps at Chicago also show somewhat less variation. Index numbers of seasonal variation in prices of meat scraps range from a low of 95 in May to a high of 104 in August; however, the index was 103 in January. These data tend to indicate the influence of seasonal requirements for meat scraps and tankage rather than a clear cut seasonal pattern of prices associated with variation in supplies, as for some other feeds.

Index numbers of seasonal variation in the price of fish meal quoted for Buffalo (f. o. b. seaboard) range from a low of 94 in July to a high of 105 in February. These prices reflect, to some extent, the variation in production and disappearance of fish meal which is highly seasonal. Index numbers of seasonal disappearance of fish meal for the United States are given in table 72, and reflect the low production in the first few months of the year as compared with the heavy production in June through October. Imports of meal offset this production variation to some extent, as is indicated by the seasonal pattern of disappearance. Data on stocks are not available, but variations are assumed to be of minor importance. Seasonal variation in production by regions is discussed on page 55.

Grain Protein Feeds

Index numbers of seasonal variation at Chicago for corn gluten meal and corn gluten feed indicate a slightly different pattern of prices. This difference may be due, in part, to the difference in composition of the two feeds, and their use by the various classes of livestock. Index numbers of the seasonal variation of sales, as given in table 72, refer to the total of gluten feed and meal. Meal is believed to represent approximately one-fourth of the total.

Prices of brewers' dried grains at Milwaukee indicate considerable seasonal variation, as shown in table 71, ranging from a low of 90 in June to a high of 113 in January. Similarly, production is highly seasonal, with a low of 82 in February and a high of 120 in July, as indicated in table 72. Although the seasonal pattern of production of distillers' dried grains is about the reverse of that for brewers' dried grains, the seasonal pattern of prices for distillers' dried grains at Cincinnati tends to be similar, with a seasonal high in January of

104 and a low of 97 in September (rather than June as for brewers' dried grains). These feeds are utilized mainly by dairy cattle, and prices probably reflect the seasonal requirements during the winter feeding period.

Wheat Millfeeds

Index numbers of seasonal variation in the price of bran and middlings at Minneapolis show a similar pattern of monthly prices, as shown in table 71. Prices tend to reach a seasonal low around October when production is at the seasonal high (see table 72) and then tend to be high in April and May when production is low. As discussed on page 25, poultry utilizes the largest proportion of millfeeds (mainly middlings) fed during the year, followed by dairy cattle (mainly bran). Seasonal requirements of feed for poultry are heavy during spring and for dairy cattle during the winter months. Thus, the seasonal pattern of prices probably reflects both the seasonal production pattern of millfeeds and the seasonal requirements of the various kinds of livestock.

Alfalfa Meal

Index numbers of seasonal variation of sun-cured and dehydrated alfalfa meal prices at Kansas City, as given in table 71, indicate a seasonal low in June and a high in January. The seasonal pattern of production of these meals for the United States, as given in table 72, indicates that production of dehydrated alfalfa meal is highly seasonal, with heavy production during the months from May to September. As noted previously, Nebraska and Kansas are the leading producing States of dehydrated meal. For sun-cured alfalfa meal, California produced about 55 percent of the total during the 1955–56 marketing year; this accounts for the high seasonal production during the winter months.

Other

Indexes of seasonal variation in prices are given also for molasses at New York, and for beet pulp with molasses at San Francisco.

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APPENDIX

In this section, the basic data used in the several statistical analyses are presented, plus a summary table of the estimated quantities of the various byproduct feeds fed for the years beginning October 1921–56. Comparisons between actual and estimated prices are shown for the principal statistical studies discussed previously. Methods used in calculating the high-protein feed supply per animal unit and related series are discussed in detail, and a modified procedure for estimating current-crop grain placed under price support is explained.

THE DATA AND THEIR SOURCE

The variables used in the various statistical analyses are given in table 73. Current values for the total feed supply are published annually in *Grain and Feed Statistics* (*55*) and in issues of the *Feed Situation* (*54*). Data on quantities of high-protein feeds fed also may be obtained from these sources, and may be converted to soybean meal equivalent using the method outlined on pages 138–39. Table 74 indicates the unweighted tonnage of the individual byproduct feeds fed for the years beginning October. Current data on stocks owned by the Commodity Credit Corporation, required to obtain variable Q-t, are given in the *Report of Financial Conditions and Operations* (*64*) for the applicable date for the four feed grains. This report also indicates the quantity of current-crop loans outstanding as of specified dates, quantities of purchase agreement grain delivered to the CCC or placed under the loan program are indicated in various issues of the *Feed Situation* (*54*). These data are used for variable Q-s.

Index numbers of the price of livestock and livestock products are published monthly in Agricultural Prices (*51*). The series on numbers of grain-consuming animal units is published in *Animal Units of Livestock Fed Annually* (*28*). The national average price support per bushel for corn is reported in the *Feed Situation* (*54*) as well as in other reports.

COMPARISON OF ACTUAL AND COMPUTED PRICES

Comparisons between actual and computed prices, obtained from the several statistical analyses discussed previously, are summarized in tables 75–80. Footnotes to the tables indicate the analyses to which the estimated prices apply.

METHODS USED IN CALCULATING THE HIGH-PROTEIN FEED SUPPLY PER ANIMAL UNIT AND RELATED SERIES

Three series were developed to measure trends in quantities of high-protein feeds fed from 1926 to date. The first relates to tonnage fed during the October–September feeding year. Individual feeds are weighted according to the digestible protein content in relation to that of 44 percent soybean meal, and are expressed in terms of soybean meal equivalent. The second is a new series on high-protein feed consuming animal units, obtained by re-weighting the published series on grain consuming animal units by the relative use of high-protein feeds by the various kinds of livestock. The third series, that of quantity fed per animal unit, is obtained directly from the first two.

Supplies of high-protein feeds, expressed in soybean meal equivalent, are shown in table 81, grouped as oilseed meals, animal-protein, and grain-protein feeds. The tonnage of the individual feeds included in these groups are shown in table 74, which also indicates the tonnage of other byproduct feeds. Conversion of these values to soybean meal equivalent is based on digestible protein content taken from Morrison (*37*) for livestock feeding and from Ewing (*9*, pp. 60–63) for poultry feeding. A single weight for each feed was obtained by combining these two protein values on the basis of the quantities of the feeds fed to livestock and poultry for the year beginning October 1949, as given by Jennings (*27*) (see table 82). The digestible protein content of soybean meal was taken as a base of 1.00 and other feeds were expressed as a ratio of this. These weights are indicated in footnote 1, table 81.

The protein content of soybean meal has increased over the period with the shift from expeller and hydraulic processing to the solvent method. The bulk of the soybean meal sold currently contains 44 percent protein. Before 1944, soybean meal generally was sold as 41 percent meal; the weights for soybean meal were adjusted to reflect this change. To allow for the increase in digestible protein content, the factor for soybean meal was increased from 90 percent in 1943 and earlier years to 100 percent in 1953. This transition was made by increasing the protein content factor used in these calculations 1 percentage point each year, that is, from 90 in 1943 to 91 in 1944 and so on until it reached 100 percent for 1953, when it was assumed that the bulk of the meal was of 44 percent protein content. A ton of soybean meal, 44 percent protein content, is taken as a standard for high-protein feeds, and the other protein feeds are expressed in terms of equivalent tons of soybean meal. It is recognized that some feeds have various nutritive characteristics which make them more valuable than other feeds of higher protein content. In developing this series, however, protein content is the only factor considered in deriving the conversion factors.

A series of high-protein-consuming animal units also was developed for use as a basis for measuring demand and requirements of protein feeds. Grain-consuming animal units, excluding horses and mules, had previously been used as a measure of high-protein-consuming animal units. However, the former series, which is based on the relative quantities of grain and other concentrates fed, gives too heavy a weight to some livestock groups and too light a weight to others. Rations fed to hogs, for example, consist of relatively small quantities of high-protein feeds as compared with other livestock rations. The new series of high-protein-consuming animal units is based on the grain-consuming animal units for various livestock groups, as published by Jennings (*28*, p. 18), but the various groups are reweighted to reflect the importance of protein feeds fed. Horses and mules consume such small quantities of these feeds they are not included in the computation of the protein-consuming series. The five other groups were weighted on the basis of the quantity of high-protein feeds consumed relative to consumption of total feed concentrates in the year beginning October 1949 (see table 82).

TABLE 73.—*Data used in various statistical analyses that relate to byproduct feeds, 1921–56*

Year beginning October	Quantity of feed concentrates		Feed grains				High-protein feeds fed, in soybean meal equivalent [4]						Price of livestock and livestock products (Nov.–May) [6]	Grain-consuming animal units fed annually	National average price support per bushel for corn
	Total supply [1]	Total minus stocks owned by CCC [2]	Q-t minus unweighted value of Q-hpf	Q-r minus estimated value of Q-s* [3]	Q-r minus actual value of Q-s [3]	Q-r minus quantity of wheat millfeeds	Adjusted total [5]	Q-hpf minus cottonseed meal	Q-hpf minus soybean meal	Q-hpf minus linseed meal	Q-hpf minus tankage and meat scraps	Q-hpf minus gluten feed and meal			
		Q-t	Q-r	Q-fg*	Q-fg	Q-mg	Q-hpf	Qo-cm	Qo-sm	Qo-lm	Qo-t&ms	Qo-g(f&m)	P-1	AU	P-s
	Million tons	*Million tons*	*Million tons*	*Million tons*	*Million tons*	*Million tons*	*Million tons*	*Million tons*	*Million tons*	*Million tons*	*Million tons*	*Million tons*		*Millions*	*Cents*
1921	133.9	133.9	131.3	131.3	131.3	----------	2.16	1.32	--------	2.01	----------	----------	123	150	----------
1922	124.6	124.6	121.6	121.6	121.6	----------	2.44	1.48	--------	2.21	----------	----------	132	158	----------
1923	127.8	127.8	124.6	124.6	124.6	----------	2.64	1.58	--------	2.37	----------	----------	128	157	----------
1924	112.8	112.8	109.3	109.3	109.3	----------	2.86	1.61	--------	2.54	----------	----------	144	151	----------
1925	128.5	128.5	124.5	124.5	124.5	----------	3.26	1.72	--------	2.93	----------	----------	151	149	----------
1926	123.2	123.2	118.9	118.9	118.9	114.0	3.45	1.73	--------	3.13	2.74	3.05	150	153	----------
1927	123.0	123.0	119.1	119.1	119.1	114.1	3.16	1.89	--------	2.79	2.44	2.74	151	154	----------
1928	126.2	126.2	122.0	122.0	122.0	116.9	3.44	1.90	--------	3.11	2.74	3.03	160	153	----------
1929	121.6	121.6	117.4	117.4	117.4	112.3	3.47	1.86	--------	3.19	2.79	3.09	148	154	----------
1930	113.0	113.0	109.2	109.2	109.2	104.3	3.16	1.70	3.05	2.91	2.47	2.85	110	153	----------
1931	122.7	122.7	119.1	119.1	119.1	114.7	2.96	1.57	2.84	2.81	2.30	2.64	78	156	----------
1932	137.7	137.7	134.1	134.1	134.1	120.7	2.99	1.64	2.89	2.84	2.29	2.66	67	160	----------
1933	115.5	115.5	111.7	103.3	106.1	101.8	3.09	1.73	3.00	2.99	2.40	2.73	74	154	45
1934	82.6	82.6	78.9	78.9	78.6	74.5	3.08	1.86	2.84	2.93	2.46	2.80	106	131	55
1935	114.3	114.3	109.6	109.5	108.9	104.2	3.88	2.50	3.32	3.68	3.17	3.53	118	139	45
1936	89.9	89.9	84.9	84.9	84.9	80.2	4.17	2.49	3.69	3.96	3.47	3.84	124	138	55
1937	123.0	123.0	117.8	116.5	116.6	112.2	4.29	2.42	3.64	4.16	3.62	3.95	115	138	50
1938	130.3	129.3	123.9	116.6	117.5	112.7	4.48	2.88	3.57	4.33	3.75	4.11	109	149	57
1939	136.1	129.1	123.4	116.9	115.1	110.5	4.73	3.32	3.58	4.44	3.93	4.35	107	156	57
1940	140.5	129.0	122.3	119.8	119.4	114.6	5.60	4.11	4.25	5.04	4.71	5.12	123	156	60
1941	150.9	146.1	138.7	134.2	135.4	130.9	6.01	4.55	4.40	5.34	5.09	5.39	159	167	75
1942	172.5	171.2	162.4	----------	160.8	156.1	7.31	5.65	4.54	6.72	6.35	6.76	195	192	83
1943	164.8	164.8	155.7	----------	155.5	150.5	7.60	6.17	4.61	6.85	6.53	7.06	197	193	90
1944	158.2	157.5	148.4	----------	147.6	142.1	7.59	6.01	4.29	7.25	6.72	7.04	207	173	98
1945	154.4	154.3	146.0	----------	145.9	141.1	7.02	5.88	3.66	6.60	6.20	6.51	216	167	101
1946	157.6	157.3	148.7	147.5	148.0	141.0	7.24	6.09	3.76	6.96	6.42	6.58	280	160	115

1947	132.8	132.8	124.0	123.9	124.0	118.5	7.49	5.93	4.31	7.04	6.58	6.98	307	153	137
1948	167.0	166.8	156.8	146.2	143.2	138.3	8.62	6.80	4.67	8.16	7.68	8.10	286	159	144
1949	175.5	161.1	150.5	140.4	138.4	133.6	9.23	7.32	4.89	8.72	8.30	8.68	260	164	140
1950	178.8	162.8	150.9	149.4	147.8	143.0	10.39	8.90	4.84	9.84	9.42	9.75	329	168	147
1951	169.2	158.4	146.3	144.4	145.3	140.3	10.79	8.67	5.27	10.40	9.75	10.25	318	167	157
1952	167.1	160.1	148.3	135.5	137.5	132.8	10.63	8.49	5.17	10.27	9.49	10.06	278	159	160
1953	172.5	159.4	147.3	133.4	133.1	128.4	10.76	8.42	5.80	10.37	9.59	10.16	271	157	160
1954	182.2	161.5	149.8	136.9	137.3	132.7	10.53	8.61	5.11	10.17	9.35	9.91	240	162	162
1955	196.9	172.0	159.0	145.6	142.9	138.4	11.86	9.85	5.82	11.53	10.16	11.22	224	166	158
1956	201.0	171.4	157.8	144.3	142.7	138.1	12.53	10.76	5.44	12.16	10.90	11.92	237	162	150

[1] Includes total stocks of corn and sorghum grains on October 1, and of oats and barley on July 1, production of the four feed grains, imported grains, domestic wheat and rye fed, and byproduct feeds fed (unweighted).

[2] Deducts stocks owned by the Commodity Credit Corporation plus old-crop grain resealed as of May 31 for corn and March 31 for oats, barley, and sorghum grains.

[3] The variables Q-s* and Q-s represent the estimated and actual quantity of current-crop loans outstanding as of specified dates, plus purchase agreement grain delivered to the Commodity Credit Corporation or placed under the loan program. For corn, the cut-off date is taken as May 31, and for oats, barley, and sorghum grains, March 31. The actual and estimated values are given in table 84.

[4] Converted to soybean meal equivalent as described on pp. 138-139.

[5] Noncommercial milk is excluded from total high-protein feeds fed, and included in the variable Q-r.

[6] Index numbers, 1910-14=100.

TABLE 74.—*Byproduct feeds: Estimated quantities fed, 1921–56* [1]

Byproduct feed	Year beginning October											
	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932
High-protein:	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
Oilseed meal:												
Soybean	4	17	24	26	28	32	61	91	114	123	133	113
Cottonseed	1, 045	1, 209	1, 334	1, 559	1, 929	2, 148	1, 587	1, 922	2, 015	1, 821	1, 740	1, 680
Linseed	199	307	365	417	442	426	493	439	368	334	204	202
Peanut	16	10	6	15	12	10	22	18	35	18	14	17
Copra	61	87	86	68	89	87	95	110	110	96	75	95
Total oilseed meal	1, 325	1, 630	1, 815	2, 085	2, 500	2, 703	2, 258	2, 580	2, 642	2, 392	2, 166	2, 107
Animal and fish:												
Tankage	----	----	----	----	----	----	----	----	----	----	----	----
Meat scraps	----	----	----	----	----	----	----	----	----	----	----	----
Total tankage and meat scraps	----	----	----	----	----	640	655	630	620	625	600	635
Fish [2]	----	----	----	----	----	100	113	148	151	121	107	130
Milk:												
Commercial [3]	----	----	----	----	----	65	80	90	105	105	110	115
Non-commercial [4]	----	----	----	----	----	1, 970	1, 820	1, 925	1, 925	2, 005	2, 060	2, 080
Total milk	----	----	----	----	----	2, 035	1, 900	2, 015	2, 030	2, 110	2, 170	2, 195
Total animal and fish	2, 550	2, 570	2, 625	2, 650	2, 720	2, 775	2, 668	2, 793	2, 801	2, 856	2, 877	2, 960

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Grain:												
Corn gluten						657	707	675	628	505	539	553
Dried grains:												
Brewers'						8	8	7	7	6	5	18
Distillers'						86	79	93	90	79	71	59
Total grain	550	555	630	600	740	751	794	775	725	590	615	630
Total high-protein	4, 425	4, 775	5, 070	5, 335	5, 960	6, 229	5, 720	6, 148	6, 168	5, 838	5, 658	5, 697
Other:												
Wheat millfeeds						4, 877	5, 020	5, 079	5, 111	4, 946	4, 370	4, 368
Alfalfa meal						250	374	351	375	248	178	194
Dried and molasses beet pulp						183	183	165	211	285	193	262
Rice millfeeds						93	100	99	88	87	79	97
Miscellaneous [5]						2, 000	2, 000	2, 000	2, 000	2, 000	2, 000	2, 000
Total other	7, 300	7, 680	7, 680	7, 355	7, 460	7, 403	7, 677	7, 694	7, 785	7, 566	6, 820	6, 921
Grand total	11, 725	12, 455	12, 750	12, 690	13, 420	13, 632	13, 397	13, 842	13, 953	13, 404	12, 478	12, 618

See footnotes at end of table.

TABLE 74.—*Byproduct feeds: Estimated quantities fed, 1921–56* [1]—Continued

Byproduct feed	Year beginning October											
	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944
High-protein:	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
Oilseed meal:												
Soybean	99	267	614	532	719	1, 020	1, 276	1, 491	1, 785	3, 074	3, 323	3, 627
Cottonseed	1, 700	1, 524	1, 718	2, 099	2, 333	2, 013	1, 762	1, 862	1, 821	2, 078	1, 790	1, 982
Linseed	142	202	264	273	177	203	394	740	891	794	998	457
Peanut	11	47	48	67	50	75	38	137	71	109	111	102
Copra	117	112	128	137	118	129	179	175	71	34	33	42
Total oilseed meal	2, 069	2, 152	2, 772	3, 108	3, 397	3, 440	3, 649	4, 405	4, 639	6, 089	6, 255	6, 212
Animal and fish:												
Tankage	----	----	----	----	----	----	----	----	----	----	----	223
Meat scraps	----	----	----	----	----	----	----	----	----	----	----	569
Total tankage and meat scraps	635	560	642	634	608	667	728	802	835	877	975	792
Fish [2]	170	186	236	274	221	246	238	263	207	202	202	228
Milk:												
Commercial [3]	120	125	125	135	140	135	155	150	130	95	105	105
Non-commercial [4]	1, 955	1, 880	1, 830	1, 750	1, 840	1, 835	1, 810	1, 880	1, 780	1, 710	1, 665	1, 610
Total milk	2, 075	2, 005	1, 955	1, 885	1, 970	1, 970	1, 965	2, 030	1, 910	1, 805	1, 770	1, 715
Total animal and fish	2, 880	2, 751	2, 833	2, 793	2, 809	2, 883	2, 931	3, 095	2, 952	2, 884	2, 947	2, 735

Grain:												
Corn gluten	608	474	583	547	569	618	642	798	1, 029	992	900	918
Dried grains:												
Brewers'	70	84	97	114	102	104	100	116	174	230	231	217
Distillers'	110	160	244	231	149	149	163	206	345	356	444	634
Total grain	788	718	924	892	820	871	905	1, 120	1, 548	1, 578	1, 575	1, 769
Total high-protein	5, 737	5, 621	6, 529	6, 793	7, 026	7, 194	7, 485	8, 620	9, 139	10, 551	10, 777	10, 716
Other:												
Wheat millfeeds	4, 267	4, 413	4, 739	4, 670	4, 448	4, 762	4, 641	4, 762	4, 533	4, 739	4, 963	5, 488
Alfalfa meal	234	205	284	380	370	410	440	470	590	680	734	922
Dried and molasses beet pulp	282	249	228	290	246	339	286	311	294	294	154	175
Rice millfeeds	83	89	88	108	124	124	120	125	124	145	139	150
Miscellaneous [5]	2, 000	2, 000	2, 000	2, 000	2, 000	2, 000	2, 000	2, 000	2, 000	1, 600	1, 600	1, 600
Total other	6, 866	6, 956	7, 339	7, 448	7, 188	7, 635	7, 487	7, 668	7, 541	7, 458	7, 590	8, 335
Grand total	12, 603	12, 577	13, 868	14, 241	14, 214	14, 829	14, 972	16, 288	16, 680	18, 009	18, 367	19, 051

See footnotes at end of table.

TABLE 74.—*Byproduct feeds: Estimated quantities fed, 1921–56* [1]—Continued

Byproduct feed	Year beginning October											
	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954 [6]	1955	1956
High-protein:	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
Oilseed meal:												
Soybean	3, 655	3, 745	3, 383	4, 158	4, 517	5, 718	5, 640	5, 510	4, 965	5, 428	6, 042	7, 093
Cottonseed	1, 433	1, 434	1, 953	2, 271	2, 382	1, 853	2, 650	2, 671	2, 926	2, 405	2, 511	2, 216
Linseed	563	370	606	620	670	732	520	478	526	488	439	486
Peanut	90	98	122	96	94	130	99	44	63	18	26	46
Copra	69	190	177	171	204	226	220	213	196	182	160	181
Total oilseed meal	5, 810	5, 837	6, 241	7, 316	7, 867	8, 659	9, 129	8, 916	8, 676	8, 521	9, 178	10, 022
Animal and fish:												
Tankage	178	188	228	244	231	242	248	251	243	297	328	303
Meat scraps	567	552	595	610	611	640	698	781	835	1, 042	1, 229	1, 182
Total tankage and meat scraps	745	740	823	854	842	882	946	1, 032	1, 078	1, 339	1, 557	1, 485
Fish [2]	213	202	236	288	324	332	438	390	438	395	464	404
Milk:												
Commercial [3]	100	120	90	110	115	100	110	115	395	170	155	150
Noncommercial [4]	1, 520	1, 475	1, 415	1, 400	1, 400	1, 350	1, 265	1, 250	1, 215	1, 160	1, 120	1, 100
Total milk	1, 620	1, 595	1, 505	1, 510	1, 515	1, 450	1, 375	1, 365	1, 610	1, 330	1, 275	1, 250
Total animal and fish	2, 578	2, 537	2, 564	2, 652	2, 681	2, 664	2, 759	2, 787	3, 126	3, 064	3, 296	3, 139

Grain:												
Corn gluten	856	1, 097	853	866	916	1, 066	911	955	1, 001	1, 034	1, 072	1, 010
Dried grains:												
Brewers'	213	229	228	233	233	241	223	224	228	238	246	236
Distillers'	326	410	353	334	352	642	339	186	244	251	286	290
Total grain	1, 395	1, 736	1, 434	1, 433	1, 501	1, 949	1, 473	1, 365	1, 473	1, 523	1, 604	1, 536
Total high-protein	9, 783	10, 110	10, 239	11, 401	12, 049	13, 272	13, 361	13, 068	13, 275	13, 108	14, 078	14, 697
Other:												
Wheat millfeeds	4, 896	6, 098	5, 480	4, 917	4, 754	4, 818	4, 974	4, 720	4, 669	4, 567	4, 487	4, 622
Alfalfa meal	1, 192	1, 040	999	1, 122	1, 094	1, 218	1, 178	1, 043	1, 210	1, 324	1, 243	1, 152
Dried and molasses beet pulp	218	285	297	332	352	443	396	385	497	554	500	525
Rice millfeeds	155	166	178	190	214	187	243	263	273	303	238	257
Miscellaneous [5]	1, 700	2, 000	2, 000	2, 300	2, 550	2, 400	2, 750	3, 350	3, 600	3, 800	3, 500	3, 400
Total other	8, 161	9, 589	8, 954	8, 861	8, 964	9, 066	9, 541	9, 761	10, 249	10, 548	9, 968	9, 956
Grand total	17, 944	19, 699	19, 193	20, 262	21, 013	22, 338	22, 902	22, 829	23, 524	23, 656	24, 046	24, 653

[1] For detailed explanation of the various series, see tables 2–18.

[2] Includes fish meal and scrap plus condensed fish solubles (solids basis) beginning 1943, and homogenized condensed fish beginning 1950.

[3] Includes dried and concentrated skim milk and buttermilk, dried whey, and beginning January 1954, concentrated and condensed whey.

[4] Includes the dry-weight equivalent of skim milk, buttermilk, whole milk, and whey fed on farms where produced.

[5] Includes estimated quantities of hominy feed, oat millfeeds, molasses, and screenings fed to livestock.

[6] Revised. Unrevised data on which the analyses were based are as follows: tankage 235; meat scraps 838; total tankage and meat scraps 1,073; total animal and fish 2,798; total high-protein 12,842; alfalfa meal 1,321; total other 10,545 and grand total 23,387.

TABLE 75.—*High-protein feeds: Index numbers of wholesale prices, November to May, actual and computed, 1921–56*

[1935–39=100]

Period beginning November	Actual	Computed with observations expressed as— Logarithms [1]	First differences of logarithms [2]	Period beginning November	Actual	Computed with observations expressed as— Logarithms [1]	First differences of logarithms [2]
1921	133	109	--------	1939	106	95	97
1922	145	129	156	1940	98	106	107
1923	131	120	131	1941	137	139	129
1924	128	142	151	1942 [3]	137	176	164
1925	123	134	109	1943 [3]	162	182	144
1926	121	140	130	1944 [3]	161	178	154
1927	150	143	137	1945 [3]	166	185	180
1928	148	148	150	1946	234	235	207
1929	131	139	144	1947	283	279	283
1930	96	104	109	1948	227	238	222
1931	59	69	68	1949	221	221	210
1932	54	55	47	1950 [4]	240	283	271
1933	76	68	70	1951 [4]	272	273	232
1934	111	106	119	1952 [4]	279	229	232
1935	83	100	87	1953	251	225	250
1936	128	122	104	1954	225	198	235
1937	94	91	90	1955	193	190	193
1938	92	92	99	1956	192	197	195

[1] Based on analysis (25c), page 87.

[2] Based on analysis (25c), page 86.

[3] Excluded from statistical analyses since price ceilings, regulated by the Office of Price Administration, were in effect for most byproduct feeds. Price ceilings on fish and animal byproduct feeds were introduced on January 20, 1942, and by May, most of the other byproduct feeds had maximum price ceilings. Price controls lapsed on July 1, 1946, but were reinstated for some byproduct feeds for a short period before controls were discontinued in mid-October, 1946.

[4] Although price ceilings were established by the Office of Price Stabilization for certain byproduct feeds early in 1951, prices in general were below ceilings during the year beginning October 1950. During the year beginning October 1951, prices of many byproduct feeds were at about the maximum permitted under price regulations. For the year beginning October 1952, most feed prices were somewhat below the ceilings, and in March 1953, all feed prices were decontrolled.

TABLE 76.—*Corn: Price per bushel received by farmers, November to May, actual and computed, 1921–56*

Period beginning November	Actual	Computed with observations expressed as—		Period beginning November	Actual	Computed with observations expressed as—	
		Logarithms [1]	First differences of logarithms [2]			Logarithms [1]	First differences of logarithms [2]
	Cents	*Cents*	*Cents*		*Cents*	*Cents*	*Cents*
1921	51	50	--------	1939	55	55	50
1922	73	72	72	1940	58	61	56
1923	76	65	64	1941	74	76	76
1924	108	92	104	1942 [3]	90	92	89
1925	69	72	80	1943 [3]	112	101	100
1926	66	82	79	1944 [3]	107	96	104
1927	83	84	74	1945 [3]	115	99	118
1928	83	85	83	1946	138	127	147
1929	78	84	84	1947	220	193	207
1930	60	64	63	1948	120	136	149
1931	33	34	35	1949	118	130	114
1932	23	22	22	1950	155	171	153
1933	45	39	40	1951	167	167	152
1934	83	90	99	1952	147	137	137
1935	56	57	49	1953	142	140	152
1936	106	102	97	1954	138	117	126
1937	51	47	49	1955	121	104	115
1938	44	49	56	1956	121	107	123

[1] Based on analysis (26e), page 87.
[2] Based on analysis (26c), page 86.
[3] Excluded from statistical analyses since price ceilings on corn, regulated by the Office of Price Administration, were in effect from January 1943 to July 1, 1946.

TABLE 77.—*Cottonseed meal: Wholesale price per ton, bagged, at Memphis, November to May, actual and computed, 1921–56*

Period beginning November	Actual	Computed with observations expressed as— Logarithms [1]	Computed with observations expressed as— First differences of logarithms [2]	Period beginning November	Actual	Computed with observations expressed as— Logarithms [1]	Computed with observations expressed as— First differences of logarithms [2]
	Dollars	*Dollars*	*Dollars*		*Dollars*	*Dollars*	*Dollars*
1921	41	34	--------	1939	30	27	26
1922	44	41	51	1940	26	30	30
1923	42	36	39	1941	37	41	36
1924	38	42	49	1942 [3]	39	52	45
1925	32	34	29	1943 [3]	48	60	44
1926	30	35	35	1944 [3]	48	53	42
1927	48	42	35	1945 [3]	50	64	60
1928	42	40	46	1946	73	82	62
1929	36	37	41	1947	87	90	83
1930	26	28	31	1948	63	68	63
1931	14	17	17	1949	62	63	59
1932	14	13	15	1950 [4]	81	97	87
1933	22	18	19	1951 [4]	84	78	67
1934	33	33	37	1952 [4]	76	63	69
1935	21	27	23	1953	66	59	74
1936	36	34	29	1954	67	57	66
1937	22	21	21	1955	53	51	58
1938	22	23	25	1956	56	56	57

[1] Based on analysis (29d), page 56.
[2] Based on analysis (29b), page 56.
[3] Excluded from statistical analyses. See footnote 3, table 75.
[4] See footnote 4, table 75.

In reweighting the grain-consuming animal units to obtain the series on high-protein-consuming animal units, animal units of dairy cattle are taken as the base or standard, with the grain-consuming animal units of dairy cattle weighted by 1.00. Thus, the number of animal units of dairy cattle is the same in both series. The grain-consuming animal units of the other groups of livestock are weighted on the basis of the percentage which the high-protein feeds consumed in 1949–50 was of the total concentrates consumed. These data, given in table 82, indicate that this percentage was 13.45 for dairy cattle. The relative quantities fed to other groups of livestock were less than for dairy cattle. Taking 13.45 percent for dairy cattle as a base of 100, beef cattle consumed 81.6 percent as much high-protein feed, relative to all feed concentrates, as did dairy cattle; sheep, 79.6 percent; hogs, 36.3; and poultry, 77.5 percent. The rounded values of these percentages were used as weights in converting the grain-consuming animal units. The weights applied to the grain-consuming animal units of each group were as follows: dairy cattle, 1.00; hogs, 0.35; and beef cattle, sheep, and poultry, 0.80. While these weights may not apply so well to some of the earlier years because of changes in feeding practices, it is considered desirable that the weights should be most applicable to the post-World War II years, which are so important in the high-protein feed situation. Grain-consuming animal units and high-protein feed consuming animal units for 1946–56 are shown in table 83 to illustrate this calculation.

From these two revised series, the third series is computed—the supply of high-protein feed available for livestock feeding per animal unit. This series is shown in table 81 for 1926–56.

TABLE 78.—*Soybean meal: Wholesale price per ton, bagged, at Chicago, November to May, actual and computed, 1930–56*

Period beginning November	Actual	Computed with observations expressed as— Logarithms [1]	Computed with observations expressed as— First differences of logarithms [2]	Period beginning November	Actual	Computed with observations expressed as— Logarithms [1]	Computed with observations expressed as— First differences of logarithms [2]
	Dollars	*Dollars*	*Dollars*		*Dollars*	*Dollars*	*Dollars*
1930	36	41	-------	1944 [3]	52	55	51
1931	21	24	24	1945 [3]	54	52	58
1932	23	19	18	1946	76	66	72
1933	32	26	35	1947	93	88	105
1934	38	35	35	1948	72	75	75
1935	24	30	24	1949	70	72	70
1936	44	43	37	1950 [4]	77	92	90
1937	28	28	27	1951 [4]	88	93	80
1938	25	27	27	1952 [4]	81	75	79
1939	31	28	26	1953	90	79	89
1940	28	34	35	1954	74	64	83
1941	43	46	38	1955	62	61	68
1942 [3]	41	59	48	1956	58	60	65
1943 [3]	52	62	45				

[1] Based on analysis (32d), page 113.
[2] Based on analysis (32b), page 113.
[3] Excluded from statistical analyses. See footnote 3, table 75.
[4] See footnote 4, table 75.

TABLE 79.—*Linseed meal: Wholesale price per ton, bagged, at Minneapolis, November to May, actual and computed, 1921–56*

Period beginning November	Actual	Computed [1]	Period beginning November	Actual	Computed [1]
	Dollars	*Dollars*		*Dollars*	*Dollars*
1921	46		1939	32	31
1922	47	47	1940	28	27
1923	42	41	1941	39	33
1924	43	49	1942 [2]	46	50
1925	46	38	1943 [2]	46	44
1926	46	50	1944 [2]	46	62
1927	49	45	1945 [2]	47	43
1928	55	54	1946	84	70
1929	53	58	1947	87	85
1930	33	43	1948	72	72
1931	29	27	1949	71	66
1932	21	23	1950 [3]	66	86
1933	31	32	1951 [3]	74	75
1934	40	43	1952 [3]	79	66
1935	26	31	1953	74	76
1936	44	34	1954	67	69
1937	41	36	1955	58	65
1938	39	40	1956	58	58

[1] Based on analysis (33b), page 115, and computed with observations expressed as first differences of logarithms.
[2] Excluded from statistical analysis. See footnote 3, table 75.
[3] See footnote 4, table 75.

TABLE 80.—*Standard spring wheat middlings: Wholesale price per ton, bagged, at Minneapolis, November to May, actual and computed, 1926–56*

Period beginning November	Actual	Computed [1]	Period beginning November	Actual	Computed [1]
	Dollars	*Dollars*		*Dollars*	*Dollars*
1926	27		1942 [2]	36	44
1927	33	30	1943 [2]	38	37
1928	27	32	1944 [2]	38	29
1929	26	26	1945 [2]	38	49
1930	16	21	1946	49	37
1931	12	10	1947	74	78
1932	9	8	1948	51	58
1933	16	15	1949	47	52
1934	27	29	1950 [3]	54	60
1935	16	16	1951 [3]	64	50
1936	35	26	1952 [3]	55	53
1937	20	18	1953	50	54
1938	19	21	1954	45	46
1939	22	22	1955	41	37
1940	21	21	1956	43	39
1941	34	32			

[1] Based on analysis (37b), page 128.
[2] Excluded from statistical analysis. See footnote 3, table 75.
[3] See footnote 4, table 75.

TABLE 81.—*High-protein feeds: Quantity available for feeding, high-protein feed-consuming animal units, and quantity fed per animal unit, 1926-56*

Year beginning October	Quantity available for feeding, soybean meal equivalent: Oilseed meal	Animal protein	Grain protein	Total [1]	Animal units fed annually [2]	Quantity per animal unit
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*Millions*	*Pounds*
1926	2, 112	2, 274	441	4, 827	83. 0	116
1927	1, 755	2, 214	468	4, 437	83. 2	107
1928	2, 011	2, 319	454	4, 784	84. 2	114
1929	2, 070	2, 323	425	4, 818	86. 2	112
1930	1, 874	2, 341	346	4, 561	85. 5	107
1931	1, 709	2, 334	361	4, 404	87. 7	100
1932	1, 653	2, 422	370	4, 445	90. 5	98
1933	1, 613	2, 396	452	4, 461	88. 4	101
1934	1, 703	2, 290	402	4, 395	78. 3	112
1935	2, 224	2, 416	516	5, 156	82. 5	125
1936	2, 485	2, 414	495	5, 394	80. 8	134
1937	2, 743	2, 375	461	5, 579	81. 3	137
1938	2, 807	2, 470	492	5, 769	86. 8	133
1939	2, 964	2, 522	512	5, 998	90. 2	133
1940	3, 594	2, 684	634	6, 912	92. 0	150
1941	3, 830	2, 555	867	7, 252	99. 2	146
1942	5, 148	2, 522	838	8, 508	112. 3	152
1943	5, 295	2, 604	866	8, 765	113. 3	155
1944	5, 350	2, 402	966	8, 718	106. 0	164
1945	5, 049	2, 263	773	8, 085	101. 5	159
1946	5, 082	2, 223	966	8, 271	97. 4	170
1947	5, 389	2, 301	791	8, 481	92. 8	183
1948	6, 396	2, 414	792	9, 602	96. 3	199
1949	6, 920	2, 456	831	10, 207	99. 0	206
1950	7, 797	2, 466	1, 069	11, 332	101. 3	224
1951	8, 224	2, 638	817	11, 679	102. 0	229
1952	8, 079	2, 657	767	11, 503	100. 2	230
1953	7, 841	2, 948	826	11, 615	100. 2	232
1954	7, 809	2, 684	853	11, 346	101. 5	224
1955	8, 471	3, 278	897	12, 646	104. 4	242
1956	9, 346	3, 095	857	13, 298	102. 9	258

[1] Soybean meal equivalent (44 percent protein content) obtained on basis of digestible protein using the following factors: *soybean meal* 1943 and earlier years, 0.90; this factor was increased by one percentage point in each of the succeeding 10 years, to allow for increasing protein content, to a factor of 1.00 in 1953 and subsequent years; *cottonseed meal*, 0.8; *linseed meal*, 0.75; peanut meal, 1.0; *copra meal*, 0.4; *tankage and meat scraps*, 1.1; *fish byproducts*, 1.45; *dried milk products*, 0.7; *gluten feed, meal and corn oil meal*, 0.6; *brewers' dried grains*, 0.45; *distillers' dried grains*, 0.5.

[2] High-protein feed-consuming livestock. Based on animal units of grain-consuming livestock, excluding horses and mules, adjusted for importance of high-protein feeds in total concentrates fed. The following factors were applied to the grain-consuming livestock animal units: dairy cattle, 1.00; beef cattle, sheep, and poultry, 0.80; and hogs, 0.35. For basis of these data, see tables 82 and 83.

TABLE 82.—*High-protein feeds consumed by specified groups of livestock as compared with total concentrates fed, year beginning October, 1949* [1]

Class of livestock	Concentrates fed			High-protein feeds as a percentage of total
	High-protein feeds, soybean meal equivalent	All other	Total	
	1,000 tons	*1,000 tons*	*1,000 tons*	*Percent*
Dairy cattle	2, 829	18, 204	21, 033	13. 45
Beef cattle	1, 152	9, 352	10, 504	10. 97
Sheep	60	500	560	10. 71
Hogs	2, 298	44, 764	47, 062	4. 88
Poultry	3, 314	28, 455	31, 769	10. 43

[1] Compiled from Jennings (*27*).

TABLE 83.—*Grain-consuming and high-protein consuming animal units, excluding horses and mules, 1946–56*

Year beginning October	Dairy cattle	Beef cattle	Sheep	Hogs	Poultry	Total (excluding horses and mules)
Grain-consuming animal units: [1]	*Million units*	*Million units*	*Million units*	*Million units*	*Million units*	*Million units*
1946	30. 1	14. 8	1. 4	58. 2	42. 5	147. 0
1947	28. 9	13. 2	1. 2	58. 0	40. 1	141. 4
1948	28. 1	14. 7	1. 1	61. 3	42. 6	147. 8
1949	28. 2	14. 8	1. 0	66. 2	43. 7	153. 9
1950	28. 0	15. 6	1. 0	70. 1	44. 3	159. 0
1951	27. 6	17. 3	1. 1	69. 0	44. 4	159. 4
1952	28. 2	20. 2	1. 1	59. 7	42. 6	151. 8
1953	28. 6	19. 5	1. 1	57. 8	43. 6	150. 6
1954	28. 0	20. 5	1. 1	64. 1	42. 2	155. 9
1955	27. 7	20. 6	1. 1	65. 9	45. 3	160. 6
1956	27. 3	20. 8	1. 1	63. 5	44. 8	157. 5
High-protein feed consuming animal units: [2]						
1946	30. 1	11. 8	1. 1	20. 4	34. 0	97. 4
1947	28. 9	10. 6	1. 0	20. 2	32. 1	92. 8
1948	28. 1	11. 7	. 9	21. 5	34. 1	96. 2
1949	28. 2	11. 8	. 8	23. 2	35. 0	99. 0
1950	28. 0	12. 5	. 8	24. 5	35. 5	101. 3
1951	27. 6	13. 8	. 9	24. 2	35. 5	102. 0
1952	28. 2	16. 2	. 9	20. 9	34. 0	100. 2
1953	28. 6	15. 6	. 9	20. 2	34. 9	100. 2
1954	28. 0	16. 4	. 9	22. 4	33. 8	101. 5
1955	27. 7	16. 5	. 9	23. 1	36. 2	104. 4
1956	27. 3	16. 6	. 9	22. 2	35. 9	102. 9

[1] Grain-consuming animal units as given by Jennings (*28*, p. 18).
[2] High-protein feed consuming animal units computed from grain-consuming units using the following weights: dairy cattle, 1.00; beef cattle, 0.80; sheep, 0.80; hogs, 0.35; poultry, 0.80.

MODIFIED PROCEDURE FOR ESTIMATING CURRENT-CROP GRAIN PLACED UNDER PRICE SUPPORT

Estimation of current-crop grain under price support by use of equation (24a) is not satisfactory for certain years in which quantities of concentrates are very large in relation to the level of demand. The particular function fitted to the data does not allow for a maximum limit to the quantity of current-crop grain placed under support for a given year. Thus, this function does not reflect the theoretical relationship outlined as plausible by this author (*31*) in an analysis of the price support program. But it did not seem reasonable to specify such a function, as only nine years of observations were included in the analysis and important factors were not readily quantifiable.

The alternative approach adopted was to use the function, but to check the estimated quantities of current-crop grain under support against corresponding values of the demand curve for feed use. Estimates for 1933-52, excluding the years during World War II, are reasonably close to actual values, as indicated in table 84. For subsequent years, the function was less adequate. The nature of the modified estimating function is illustrated for selected years in table 85. For 1949, the feed concentrate variable Q t equaled 160.9 million tons. Using this value in equation (24a), plus the relevant values of (1) the price support level for corn; (2) the price of livestock

TABLE 84.—*Current-crop grain placed under support: Actual and estimated, 1933-56* [1]

Crop of	Actual	Estimated [2]	Crop of	Actual	Estimated [2]
	Million tons	*Million tons*		*Million tons*	*Million tons*
1933	5.6	8.4	1945	0.1	3.6
1934	.3	.0	1946	.7	1.2
1935	.7	.1	1947	.0	.1
1936	.0	.0	1948 [3]	13.6	10.6
1937 [3]	1.2	1.3	1949 [3]	12.1	10.1
1938 [3]	6.4	7.3	1950	3.1	1.5
1939 [3]	8.3	6.5	1951	1.1	1.9
1940 [3]	2.9	2.5	1952 [3]	10.8	12.8
1941 [3]	3.3	4.5	1953 [5]	14.2	[4] 13.9
1942	1.6	8.9	1954	12.5	[4] 12.9
1943	.2	6.3	1955 [5]	16.1	[4] 13.4
1944	.8	5.4	1956 [5]	15.1	[4] 13.5

[1] Data refer to quantity of loans outstanding as of specified dates, plus purchase agreement grain delivered to CCC or placed under the loan program. For corn, the cut-off date is taken as May 31 of the October–September crop year indicated; and for oats, barley, and sorghum grains, March 31.

[2] Estimated from equation (24a), page 83, except where noted.

[3] Year included in the analysis.

[4] Approximated as shown in table 85 and described on pages 155-158.

[5] Preliminary.

TABLE 85.—*Feed grains: Current-crop grain under support and derived nonsupport quantity in relation to specified levels of Q–t, specified years*

Q–t [1]	1949 Placed under support [2]	1949 "Fed" [3]	1951 Placed under support [2]	1951 "Fed" [3]	1953 Placed under support [2]	1953 "Fed" [3]	1954 Placed under support [2]	1954 "Fed" [3]
	Mil. tons	*Mil. tons*	*Mil. tons*	*Mil. tons*	*Mil. tons*	*Mil. tons*	*Mil. tons*	*Mil. tons*
135	0.4	134.6	0.1	134.9	0.8	134.2	2.5	132.5
140	.9	139.2	.2	139.8	1.6	138.4	4.8	135.2
145	1.6	143.4	.4	144.6	3.0	142.0	8.9	136.1
146	1.8	144.2	.5	145.5	3.4	142.6	10.1	135.9
147	2.0	145.0	.5	146.5	3.9	143.1	11.4	135.6
148	2.3	145.7	.6	147.4	4.4	143.6	[4] 12.9	135.1
149	2.6	146.4	.6	148.4	4.9	144.1	14.5	134.5
150	2.9	147.1	.7	149.3	5.5	144.5	16.3	133.7
155	5.2	149.8	1.3	153.7	9.9	145.1	29.3	125.7
156	5.8	150.2	1.5	154.5	11.1	144.9	32.8	123.2
157	6.5	150.5	1.6	155.4	12.5	144.5	36.8	120.2
158	7.3	150.7	1.8	156.2	[4] 13.9	144.1	41.2	116.8
(158.4)			*(1.9)*	*(156.5)*				
159	8.2	150.8	2.1	156.9	15.6	143.4	46.1	112.9
(159.4)					*(16.3)*	*(143.1)*		
160	9.2	150.8	2.3	157.7	17.4	142.6	51.5	108.5
(160.9)	*(10.1)*	*(150.8)*						
161	10.2	150.8	2.6	158.4	19.5	141.5	57.6	103.4
(161.5)							*(60.8)*	*(100.7)*
162	11.4	150.6	2.9	159.1	21.8	140.2	64.3	97.7
163	12.7	150.3	3.2	159.8	24.3	138.7	71.7	91.3
164	14.2	149.8	3.6	160.4	27.1	136.9	79.9	84.1
165	15.8	149.2	4.0	161.0	30.2	134.8	89.1	75.9

[1] Total quantity of feed concentrates at start of marketing year, minus stocks owned by CCC plus old-crop grain resealed as of May 31 for corn and March 31 for oats, barley, and sorghum grains. Figures in brackets are Q–t values for specific years, and estimates for these values are in italics and in brackets.

[2] Estimated current-crop grain under support as of specified date (see table 84, footnote 1) with varying values of Q–t, but with (1) price support for corn, (2) price of livestock products, and (3) animal units for the specified year.

[3] Derived quantity fed obtained by subtracting the estimated quantity placed under support from Q–t.

[4] Approximation of quantity placed under support, assuming that the quantity "fed" curve does not become positively sloped to a greater extent than was true for 1953. The solution is one associated with a quantity placed under support such that the quantity "fed" is only slightly less than for smaller Q–t values.

products; and (3) animal units, the estimated quantity of current-crop grain under support was 10.1 million tons. If this value is subtracted from 160.9 million tons, a derived quantity "fed" is obtained which equals 150.8 million tons.[14] A series of estimates for the quantity of grain placed under support and the derived quantity fed can be obtained by varying the quantity fed variable Q–t, while holding constant the value of the three variables noted above which refer to the particular year under consideration.

As the feed concentrate variable Q–t is increased, the estimated quantities under support increase at an increasing rate and the derived quantity fed series increases to a maximum and then decreases. The shape of this derived quantity fed curve is not satisfactory on theoretical grounds, and the decreasing phase is untenable. By performing calculations similar to that illustrated for the year 1949, we can determine if the estimate obtained from equation (24a) is reasonable in a given year.

For 1949 and 1951, table 85 suggests that equation (24a) gives a reasonable estimate. The derived quantity fed curve is still increasing at the value of the Q–t variable. The same is true for 1952 (not shown). But for 1953 and 1954, the derived quantity fed curve is decreasing for the respective Q–t values estimated by holding the other three variables in equation (24a) at their specified values. It also is decreasing in 1955 and 1956 (not shown). For the years in which the derived quantity fed curve is decreasing, the quantity placed under support is taken as that value associated with a derived quantity fed which is about 1 million tons less than the maximum of the derived quantity fed curve. For example, the maximum derived quantity fed for 1953 is 145.1 million tons, and the approximated quantity of current-crop grain placed under support is 13.9, associated with a derived quantity fed of 144.1 million tons. Similar estimates are made for 1954, 1955 and 1956.

Thus, for years in which equation (24a) gives unreasonable estimates of the current-crop grain placed under support, a check of the type illustrated in table 85 should be made. The approximation of the quantity under support can be obtained by assuming that for such years, the quantity under support is associated with a derived quantity fed which is slightly less than the maximum of the derived quantity fed series. This only is a rough approximation since, at this range, slight changes in the Q–t variable are associated with large changes in the estimated quantity of current-crop grain placed under support.

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[14] The derived quantity "fed" includes quantities of grain for nonfeed uses, including commercial storage; an implicit assumption of the analysis is that the demand for total nonfeed uses has an elasticity equal to that for feed uses.

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