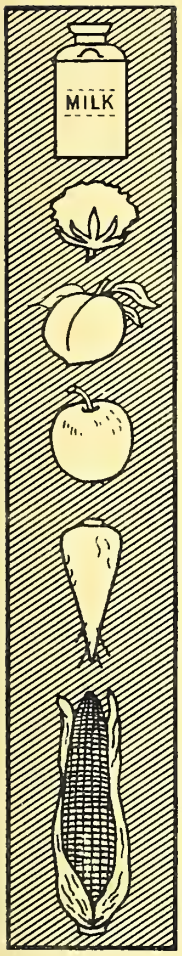

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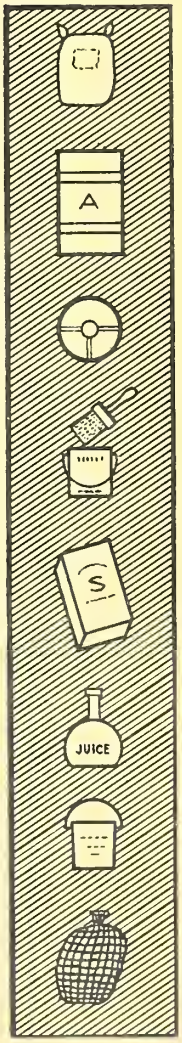
FARM PRODUCTS AND BY PRODUCTS FOR INDUSTRIAL USE



BUREAU OF AGRICULTURAL CHEMISTRY AND ENGINEERING

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C O N T E N T S

FOREWORD

Industrial use of farm products has made rapid strides in the last few years. For example, there has been a constantly increasing use of soybeans as an industrial raw material. The factory consumption of soybean oil has increased practically 10-fold since 1931. Some 200 million bushels of corn is now processed annually for the manufacture of foods, beverages, starch, oil, and other products. Cottonseed was at one time merely a waste if not a nuisance. Then processing for the recovery of cottonseed oil began. Now the cash value of the seed equals about 16 percent of the total cotton crop value. Some synthetic fibers and cellulose plastics are manufactured in large quantities from cotton linters. Acetone, butyl and other alcohols, and organic acids are made by controlled fermentation of corn. Furfural is made from waste oat hulls by processes which originated in the Department laboratories.

In May 1935, a committee was appointed by the Secretary of Agriculture to assemble facts and statistics relating to industrial utilization of farm products. This committee prepared a report which was issued in October 1935, under the title "Preliminary Estimates of Farm Products, By-products, and Wastes Available for Industrial Use." It had been the intention, in due course, to revise that report and present such later facts and figures as had become available.

In 1938 this whole subject came under broader consideration as a result of Congressional action providing for four regional research laboratories and for a comprehensive survey of research already in progress in this field. The fruits of this survey were published April 6, 1939, as Senate Document No. 65, 76th Congress, 1st Session, entitled "Regional Research Laboratories, Department of Agriculture." That report presented a comprehensive picture of the supply and utilization of all the important agricultural products and byproducts.

In order to reduce such information to a more compact form, and at the same time accomplish the purposes of a revision of the Department's 1935 report, basic data presented in the lengthy Senate Document have been condensed for use in this present statement, which is intended to convey a brief summary of background facts that will be useful to those who wish information on the utilization of farm products and byproducts in industry. Where more recent figures or more complete information on production or utilization were available they have been incorporated. Since statistics are revised annually, later figures than those given may be obtained as necessity arises, by addressing an inquiry to the Bureau of Agricultural Economics or the Agricultural Marketing Service, U. S. Department of Agriculture, Washington, D. C.

CORN

Three distinctly different types of corn--sweet corn, popcorn, and field corn--are cultivated in the United States. The following considerations of corn as a farm commodity are limited to field corn, which constitutes one of the major agricultural crops in this country.

The United States grows about 50 percent of the world's production of corn. The average annual production of this cereal (in grain equivalent to entire acreage) in this country in the 10-year period 1928-37 was about 2,310 million bushels, ranging from about 2,931 million bushels in 1932, the largest crop since 1920, to approximately 1,461 million bushels in 1934, a drought year, the smallest crop since 1881. In 1938 the production was about 2,562 million bushels, compared with around 2,619 million bushels in 1939. The average annual production of corn harvested as grain in the 10-year period 1928-37 was about 1,983 million bushels. In 1938 and 1939 the amounts harvested for grain were 2,303 and 2,360 million bushels, respectively, or about 90 percent of the total production expressed in grain equivalent to entire acreage.

The Corn Belt, so-called, is the center of production, and consists of a broad belt from Nebraska eastward to central Ohio. Iowa produces the greatest amount of corn.

The farm value of corn in 1928 was about 2,240 million dollars, based on the season average price per bushel received by farmers of 84 cents. In 1938 the farm value was only about 1,280 million dollars, based on an average price of only 50.3 cents a bushel. Corn is the third most important cash crop in the United States, ranking next to wheat. The cash income received by farmers from the sale of corn in 1937 was about 224 million dollars, compared with around 269 million dollars in 1938, and 326 million in 1939. These figures represent approximately 7.0 percent of the farm cash income from all crop sources.

The average annual acreage of corn harvested in the 10-year period 1928-37 was about 99.8 million acres, of which about 82.8 million acres was harvested for grain. The total acreage in 1938 was about 92.2 million and in 1939 about 88.8 million acres. In 1939 about 78.9 million acres was harvested for grain, representing a production of about 2,360 million bushels; approximately 4.2 million acres was harvested for silage (about 31.2 million tons of silage); and about 5.7 million acres was used for hogging down, grazing, and forage.

The carry-over, total supply, net exports, domestic disappearance, and the farm price of corn in recent years are given in table 1.

Table 1.--Supply, distribution and price of corn in the United States

Year beginning Oct.	Carry-over (farm and commercial) Oct. 1	Total supply	Net exports[1/]	Domestic disappearance	Farm price per bushel
	1,000 bushels	1,000 bushels	1,000 bushels	1,000 bushels	Cents
1928	92,200	2,757,716	41,399	2,567,977	84
1929	148,340	2,669,372	8,119	2,524,921	80
1930	136,332	2,216,753	1,733	2,047,249	60
1931	167,771	2,743,382	4,058	2,468,991	32
1932	270,333	3,201,614	8,713	2,806,580	32
1933	386,321	2,785,953	3,928	2,444,935	52
1934	337,090	1,798,213	-35,812[2/]	1,768,949	82
1935	65,076	2,368,823	-20,228[2/]	2,209,504	66
1936	179,547	1,686,636	-103,238[2/]	1,723,652	105
1937	66,222	2,717,506	138,074	2,216,339	52
1938	363,093	2,905,331	33,927	2,310,522	50
1939[3/]	560,882	3,151,945			

1/ Corn, including meal.
2/ Net imports.
3/ Preliminary.

The estimated average annual disposal of corn in the two 5-year periods, 1925-29 and 1930-34, including the grain equivalent of corn hogged off or fed as silage, are given in table 2.

Table 2.--Corn utilization, 1925-29 and 1930-34

Use	1925-29		1930-34	
	Average used annually	Percent	Average used annually	Percent of total
	Million bushels		Million bushels	
Horses and mules on farms.....	397	15.1	315	13.7
Cattle on farms.....	544	20.7	548	23.8
Hogs on farms.....	1,062	40.4	914	39.7
Sheep on farms.....	17	.6	17	.7
Poultry on farms.....	264	10.0	245	10.6
Livestock not on farms.....	65	2.5	40	1.7
Families on farms.....	31	1.2	32	1.4
Seed.....	18	.7	18	.8
Exports.....	21	.8	-4[1/]	-.2[1/]
Industrial and commercial.....	210	8.0	180	7.8
Total utilization	2,629	100.0	2,305	100.0

1/ Net imports.

The "industrial and commercial" figures given in this table comprise corn used in the production of alcohol, distilled spirits, fermented malt liquors, breakfast foods, and that used by dry- and wet-process millers. The export figures are of corn and corn meal in terms of corn. Exports of corn meal were deducted from the "industrial and commercial" figures in order to avoid duplication.

In recent years, the quantity of corn fed to cattle has increased somewhat but this increase has been much more than offset by the decrease in the quantities of corn fed to horses, mules, and livestock not on farms. The replacement of draft animals by motor power has decreased the demand for corn for feeding horses and mules. During the 5-year period 1925-29 horses and mules on farms consumed an average of approximately 397 million bushels of corn. During the following 5 years (1930-34) the average annual consumption by these animals on farms was about 82 million bushels (21 percent) less than the average annual consumption in the preceding 5 years. About 90 percent of the corn consumed in this country is used in feeding livestock and poultry.

There are several commercial channels for corn, including dry-milling, wet-milling, and the brewing and distilling industries. In dry-milling, the tempered grain is separated into endosperm, bran, and germ. From the endosperm comes corn meal, hominy, grits, corn flour, and breakfast cereals. The germ is pressed for oil, and the germ cake and bran are used in animal feeds.

According to the Bureau of the Census about 6.95 million barrels of corn meal (a barrel of degermed corn meal is equivalent to 6 bushels) was produced in 1937, as compared with about 7.22 million in 1935 and about 8.68 million barrels in 1931. These figures, however, do not include the production of mills with products valued at less than $5,000 per year. There are no official figures giving the corn meal production of the numerous small mills throughout the country. Many of them are run by water power, and it is in these small water power mills that the so-called "water-ground corn meal" is milled. This is the whole corn ground between buhr stones, the finished product containing part of the bran and most of the germ. The offal is used locally as feed. The amount of meal produced by these mills is considerable. In 1937, approximately 238.3 million pounds of breakfast foods from corn was produced compared with about 184.3 million in 1935 and about 237 million pounds in 1933. It is impossible to secure complete statistical data on the amount of corn used in the dry-milling industry, and there are no figures on custom milling or on the amounts used as cracked corn in the mixed-feed industry.

In the wet-milling industry the corn is steeped, then separated into starch, gluten, germ, and bran. Thus far wet-milling methods have developed more industrially useful materials than have dry-milling methods, probably because there is a cleaner separation of the fractions in the milling process. The average annual wet-process grindings of

corn in the 10-year period beginning October, 1, 1928, and ending September 30, 1938, was about 70.8 million bushels, ranging from about 55.3 million bushels in 1934-35 to about 87.2 million in 1928-29. For the year ending September 30, 1939, the wet-process grindings amounted to about 75.5 million bushels. This amount of grindings requires the harvest from approximately 2.5 million acres of corn land, based on an average yield of 30 bushels per acre.

The sales of industrial products made by the wet-process industry for the 10-year period 1928-37 and for 1938 are shown in table 3.

Table 3.--Sales of industrial products for the 10-year period 1928-37 and for 1938

Product	1928-37 Average	1938
	Million lbs.	Million lbs.
Cornstarch	721,876	912,225
Corn sugar	696,737	412,479
Corn sirup 1/	1,009,541	1,080,266
Dextrins	86,032	80,581
Crude corn oil	35,965	15,361
Refined corn oil	84,811	113,851
Gluten feed and meal	1,114	1,036
Gluten oil meal	50	44

1/ Includes corn sirup sold to mixers and quantity used in mixed sirups.

Cornstarch has many uses. Package cornstarch sold by grocers for food and home laundry purposes accounts for the largest distribution. In 1937 the sales for these purposes alone amounted to about 147 million pounds, or about 20 percent of the total sales. The textile industry is second in consumption. In the same year (1937) the distribution to the textile industry was nearly 140 million pounds, or about 18 percent of the total sales. Other uses of cornstarch include: in baking powder, paper sizing, brewing, confectionery, explosives, adhesives, and dextrins.

Dextrins are produced by a process of "roasting" or heating starch. The uses of dextrins include: sizes for use in weaving and finishing textile fabrics; thickeners for colors used in textile printing; adhesives; and fireworks of the sparkler type.

Corn sirup and corn sugar are made from cornstarch by a chemical action known as "hydrolysis." Among the uses of corn sirup are the following: in table sirups, confectionery, jams, jellies, preserves, ice cream, pharmaceuticals, and brewing. It is also used to some extent in

the textile, tobacco, and tanning industries. Some of the uses of corn sugar are: in bakery products, ice cream, pharmaceuticals, dietetic preparations, brewing, caramel, and vinegar. It is also used in rayon and leather manufacture, and in making lactic acid.

Corn oil is obtained from the germ of the corn. The annual factory consumption of corn oil in this country between 1931 and 1938 ranged from about 42.4 million pounds in 1932 to about 83.8 million pounds in 1937. In 1938 the factory consumption was about 72.3 million pounds, distributed by classes of products as follows:

	1,000 lbs.
Compounds and vegetable cooking fats	399
Oleomargarine	556
Other edible products	57,104
Soap	2,514
Paint and varnish	118
Miscellaneous 1/	3,345
Foots and loss 2/	8,734
Total factory consumption	72,770
Total apparent disappearance	147,514

1/ Miscellaneous consumption includes uses in: Electrical insulating compositions, grinding paint pigments, leather finishing and dressing, lubricants, rubber substitutes and imitations, textile manufactures, and waterproofing cloth.

2/ Foots, or residue from refining, largely used in soap stock.

These figures show that in 1938 about 80 percent of the total factory consumption of corn oil was used in edible products.

Corn gluten feed and meal, and corn oil meal are types of feeds obtained as byproducts of wet-process milling. They are used for feeding cattle, sheep, poultry, and other domestic animals. It has been estimated that for the year beginning July 1, 1939, the supply of gluten feed and meal available for domestic use will be about 650,000 tons, compared with approximately 573,000 tons for the average annual supply in the previous 10 years.

The average annual consumption of corn in the production of alcohol and distilled liquors, and fermented malt liquors, in the 5-year period beginning July 1, 1933, and ending June 30, 1938, was approximately as follows: alcohol and distilled liquors, 24.2 million bushels; fermented malt liquors, 616 million bushels. In the year ending June 30, 1939, about 18.1 million bushels was consumed for alcohol and distilled liquors and about 7.4 million bushels for fermented malt liquors.

On the basis of an average annual production of 1,983 million bushels of corn harvested as grain in the United States in the 10-year

period 1928-37, the average annual production of dry corncobs was around 12 million tons, using a cob-to-grain ratio of 0.22 : 1.00. Only the cobs collected at mills and grain elevators would ever be available for industrial uses. Assuming that 10 percent of the corn crop harvested as grain goes to mills and elevators on the cob, the total quantity of cobs collected at these places averaged annually only about 1.2 million tons in the 10-year period 1928-37. Corncobs have been suggested for use, or have been used to a very limited extent, for making furfural, for removing oil from tin plate, for cleaning furs, for packing glassware, etc., for structural insulation, as an absorbent material, as a filler in mixed feeds, as a substitute for wood flour in the manufacture of certain molded plastics, and as a filler in the place of cork or wood flour in the manufacture of linoleum. A very small quantity of cobs of a special type is used in making smoking pipes.

It is estimated that in the 10-year period 1928-37 the average annual production of dry corn stover was around 67 million tons (using a stover-to-grain ratio of 1.2 : 1.0). Probably the only cornstalks that would ever be available for industrial uses are those from concentrated areas of production. It is assumed that the most concentrated area of production would include all the corn in Iowa, 90 percent of that in Illinois, 70 percent of that in Nebraska, Missouri, and Indiana, and 60 percent of that in Ohio. Adding these percentages of the average annual acreage of corn harvested as grain in the respective States during the 10-year period 1928-37 gives approximately 29.6 million acres. Taking Webber's average figure of 2 tons of bone-dry stover per acre in the Corn Belt (Indus. Engin. Chem. 21: 270, March 1929), and applying it to this acreage gives about 59.2 million tons of bone-dry stover. On the basis of Rommel's statement that approximately one-half of the weight of corn stover is in the leaves and husks ("Farm Products in Industry," p.124) this quantity of stover would correspond to about 29.6 million tons of bone-dry stalks. Cornstalks, like cereal straws, hulls, sugarcane bagasse, and other fibrous farm wastes, are a potential source of raw material for the manufacture of cellulose and paper pulp. In fact, cornstalks have been used in this country to a very limited extent in making paper. Insulation board is now made from cornstalks. However, the tonnage used for this purpose is relatively small.

WHEAT

The average annual production of wheat in the United States in the 10-year period 1928-37 was about 753 million bushels, ranging from about 942 million bushels in 1931 to only about 526 million in 1934, when the worst drought in more than 50 years occurred in the Great Plains area. This quantity represents about 20 percent of the average annual world production in that period, excluding the Union of Soviet Socialist Republics and China. In 1938 the production was approximately 932 million bushels and in 1939 it was reduced to around 755 million bushels. The North Central States grow about 60 percent of the total wheat produced in this country. Kansas is the principal producing State.

The farm value of this cereal in 1928 was about 913 million dollars, based on the season average price of 99.8 cents per bushel received by farmers. In 1938 the farm value was only about 514 million dollars, based on an average price of only 55.2 cents per bushel. Wheat is the second most important cash crop of American farms, ranking next to cotton. The cash income received by farmers from the sale of wheat in 1937 was approximately 605 million dollars, around 396 million dollars in 1938, and 397 million in 1939. These figures represent around 14 percent of the farm cash income from all crop sources.

The total harvested acreage of wheat in this country during the 10-year period 1928-37 averaged about 55.8 million acres. This was divided, roughly, into 38.2 million acres of winter wheat and 17.6 million acres of spring wheat. In 1938 approximately 69.9 million acres was harvested, and in 1938 the acreage was reduced to about 53.7 million acres.

For the 10-year period beginning July 1, 1928, and ending June 30, 1938, the average annual domestic wheat disappearance, including shipments to territories, was about 685 million bushels, and in the year ending June 30, 1939, the disappearance totaled around 675 million bushels. The approximate farm disposition of wheat in the United States in 1938 was as follows: 78 million bushels was used for seed, of which 71.9 million bushels was utilized by farmers on their own farms and 6.1 million was sold for seed; 131.6 million bushels was fed to livestock by producers on their own farms; 16 million bushels was ground at mills for home use or exchanged for flour; and 711.3 million bushels was sold.

What is usually considered the "wheat problem" in the United States had its beginning in the World War. Before that time a fairly stable condition in wheat growing and marketing was being approached. About 20 percent of the annual crop was sold abroad. In 1912, for instance, 730 million bushels of wheat was produced; 20 percent of this amount--about 144 million bushels--was exported. About half as much was exported in each of the two preceding years. In other words, no more wheat was grown than could be used and exported profitably.

The World War, however, changed the picture entirely. The United States, Canada, Australia, and the Argentine turned to wheat farming on a large scale. Following the war, Europe again resumed its wheat growing and our export trade suffered a severe slump.

The average annual exports of wheat, including flour in terms of wheat, and including shipments to Alaska, Puerto Rico, and the Virgin Islands, amounted to approximately 72.8 million bushels in the 10-year period, July 1928-June 1938. The average annual net exports during this period were about 62 million bushels. In the year ending June 1939, the exports totaled about 109.5 million bushels and the net exports amounted to approximately 107 million bushels.

The carry-over in the United States and the average price received by wheat producers in recent years are given in table 4.

Table 4.--Carry-over in the United States and average price received by wheat producers in recent years

Year beginning July	Carry-over million bushels	Farm price per bushel
1923-27 (average)	118	$ 1.20
1928-32 (average)	264	.69
1933	378	.74
1934	274	.85
1935	148	.83
1936	142 1/	1.03
1937	83	.96
1938	153	.56
1939	254	.....

1/ Prior to 1937 the carry-over contained some new wheat, in some years probably amounting to about 20 million bushels.

It was estimated that the world production of wheat for 1939 would be about 4,264 million bushels, which is approximately 264 million bushels more than the estimated world consumption for that period. The world carry-over on July 1, 1940, is expected to be about 1,441 million bushels, compared with about 1,165 million bushels on July 1, 1939.

Most of the sound, high-grade wheat grown and processed in recent years has been converted into food,--bread, biscuits, cakes, alimentary pastes, and cereal breakfast foods. The amount of this grain fed to livestock on the farm where grown varies widely from year to year. In commercial animal and poultry feeds containing wheat, this ingredient, in normal years, is chiefly wheat unsuitable for milling. Byproducts of the milling industry are used largely as feeds or as ingredients in mixed feeds. There is a growing use of wheat byproducts in poisoned baits for insects.

In the 10-year period 1928-37 the average annual supply of wheat mill feeds available for domestic use was about 4.67 million tons, and it is estimated that for the year beginning July 1, 1939, the supply will be about 4.75 million tons. In the 10-year period 1928-37, an annual average of approximately 475 million bushels of wheat was ground for food, and in 1938 the amount totaled about 472 million bushels. There are no official estimates giving the amount of wheat used in the United States for making breakfast foods, but it is believed that it is around 10 million bushels annually. In 1937 breakfast foods made from wheat totaled about 447 million pounds, or about 35 percent of the total output of this type of food. Relatively little wheat is used in the manufacture of distilled spirits, the quantity being only around 55,000 bushels in the year ending June 30, 1939. There are no official estimates of the amount of wheat used in making starch. The small quantities produced from wheat are usually byproducts of the manufacture of wheat gluten or gluten flour. A number of manufacturers ceased making starch from wheat during the World War and many of these have never resumed operations.

Industrial products now manufactured from wheat, other than bakery products and animal feeds, are relatively few in number and comparatively small in tonnage. This is the consequence, in part at least, of the distinctive properties of wheat which facilitate its conversion into attractive and readily available food. Thus wheat flour is the only known plant product which can be converted into a paste or dough possessing the requisite ductility, elasticity, and other physical properties to facilitate the production of leavened bread of good texture. The fairly direct route followed by wheat and wheat products from the field to the dining table, the relatively small waste en route, and the ease with which sound normal food wheat can be handled and stored against periods of shortage are factors which have contributed to the importance of wheat in domestic agriculture.

In the harvesting of wheat enormous quantities of straw are produced annually. On a basis of an average annual production of 753 million bushels of wheat harvested in the United States in the 10-year period 1928-37, the average annual production of dry straw was around 43 million tons, using a straw-to-grain ratio of 1.9 : 1.0. It is estimated that approximately 30 million tons are available annually for industrial utilization. Wheat straw, like other cereal straws, is a potential source of raw material for the manufacture of cellulose and paper pulp. In fact, this straw is used in making insulation board, corrugated fiber board, fiber shipping boxes, egg case fillers, etc. In 1935, the latest year for which official statistics are available, over 400 thousand tons of straw (mostly wheat straw) was consumed in the paper industry.

BARLEY

The average annual production of barley in the United States in the 10-year period 1928-37 was about 233 million bushels, or about 10 percent of the annual world production. In 1938 the production was about 253 million, and in 1939 it was increased to around 276 million bushels. The farm value in 1928 was approximately 186 million dollars, based on the season average price per bushel of 56.8 cents received by farmers. In 1938 the farm value was only around 95 million dollars, based on an average price of only 37.3 cents a bushel. The cash income received by farmers from the sale of this cereal in 1937 was approximately 43 million dollars, and in 1938 around 38 million dollars.

Barley is grown in appreciable quantities in 25 States with production centered in Minnesota, Wisconsin, North Dakota, South Dakota, and California. Minnesota leads in production with about 20 percent of the total. The annual acreage of barley harvested in the 10-year period 1928-37 averaged about 11.0 million acres; in 1938 about 10.5 million; and in 1939 the acreage was increased to about 12.6 million acres.

The annual exports of barley for the 10-year period 1928-37 ranged from 60.3 million bushels for the year beginning July 1928 to 4.1 million bushels for the year beginning July 1934. Imports for the same 10-year period ranged from 41 thousand to 28.7 million bushels.

Barley is used chiefly as a feed grain, being substituted for corn to some extent. It is frequently ground with oats or other grains as mixtures. As a feed it is used largely for horses and poultry and in the finishing of bacon hogs. It is estimated that of the 220.3 million bushels produced in the United States in 1937, approximately 132.7 million bushels, or about 60 percent, was used for feed and seed by producers on their own farms.

While barley constitutes no more than 6 percent of the total quantity of cereal grains produced in the United States, from the industrial point of view it is surpassed in importance among the grains only by wheat and corn. In the year ending June 30, 1939, about 57 million bushels, or around 25 percent of the total production, was used in the manufacture of fermented malt liquors. During the same period around 4.8 million bushels was consumed in making distilled spirits and about 622,000 bushels was used in the manufacture of ethyl alcohol. By far the largest consumption of malted barley is in the brewing and distilling industries, although important quantities find outlets in malt sirups, malted-milk beverages, malt flour, and other food products. Only relatively small quantities of barley are used in the manufacture of barley flour or as a breakfast food. Pearl barley is used in foods such as soups and dressings.

On a basis of an average of 233 million bushels of barley produced annually during the 10-year period 1928-37, the production of dry barley straw was around 6.7 million tons, using a straw-to-grain ratio of 1.2 : 1.0. It is estimated that 75 percent of the annual production of straw is available for industrial uses. Barley straw, like other cereal straws, is a potential source of raw material for the manufacture of cellulose and

paper pulp. It is possible that a small quantity of the straw used for the manufacture of paper and fiber board is barley straw. However, since the greater part of the barley is produced in States which have no straw pulp mills, and the quantity available elsewhere is relatively small in comparison with wheat straw and rye straw, the quantity of barley straw used for paper and fiber board would be negligible.

OATS

The average annual production of oats in the United States in the 10-year period 1928-37 was about 1,049 million bushels, or around 25 percent of the world annual production in that period. In 1938 the production was about 1,068 million bushels, compared with around 937 million bushels in 1939. The farm value of this cereal in 1928 was about 534 million dollars, based on the season average price per bushel of 40.7 cents received by farmers. In 1938 the farm value was only around 230 million dollars, based on an average price of only 21.8 cents per bushel. The cash income received by farmers from the sale of oats was approximately 67 million dollars in 1937 and around 43 million and 45 million dollars in 1938 and 1939, respectively. These figures represent about 1.5 percent of the farm cash income from all crop sources. Iowa is the principal producing State with an average annual production in the 10-year period 1928-37 of about 194 million bushels, or nearly 20 percent of the total domestic production. Other States in order of importance are Minnesota, Illinois, Wisconsin, Nebraska, Ohio, and Indiana.

The average annual acreage harvested in the 10-year period 1928-37 was about 37.5 million acres. The acreage in 1938 was about 35.7 million, and in 1939 about 33.1 million acres.

The net annual exports of oats during the past 15 years have averaged less than 10 million bushels. In the past 4 or 5 years exports have been practically nil.

Oats are the principal small grain fed to livestock. It is estimated that of the 1,162 million bushels of this cereal produced in this country in 1937, approximately 937 million bushels, or about 80 percent, were used by producers on their own farms for feed and seed. The quantity processed for breakfast food (oatmeal and rolled oats) is around 26 million bushels annually, or about 2.5 percent of the total production. Oat food products produced in 1937 comprised about 506 million pounds, or nearly 45 percent of the total output of breakfast foods. The value of these oat breakfast foods is about 25 million dollars, or nearly one-fourth that of all products in this class.

Oat hulls, a byproduct in the manufacture of rolled oats and oatmeal, are available in large quantities. It is estimated there are 135,000 to 150,000 tons of hulls available for industrial utilization. Today, oat hulls constitute the only raw material being used commercially for the production of furfural. As the yield of furfural is about 10 percent of the weight of the raw material, the potential output is 27 to 30 million pounds. Current production of furfural does not yet approach this figure. Oat hulls are a potential source of raw material for the manufacture of cellulose and paper pulp. In fact, paper has been made experimentally from this waste.

On the basis of an average of 1,049 million bushels of oats produced annually during the 10-year period 1928-37, the production of dry straw was about 21.8 million tons, using a straw-to-grain ratio of 1.3 : 1.0. Oat straw is more useful than other cereal straws as a roughage feed for livestock and comparatively little is wasted. It is not used extensively in manufacturing, and is not likely to be used in large quantities as a raw material for industrial processes in view of the great abundance of other straws.

GRAIN SORGHUMS

The grain sorghums, including kaffir, milo, feterita, durra, etc., which are among our most drought-resistant crops, have an important place in the agricultural economy of the semiarid regions of the United States. They bring a gross farm income of 5 to 6 million dollars a year. The cash farm income from grain sorghums in 1938 was around 7.5 million dollars and in 1939 about 5.5 million dollars. The total land devoted to grain sorghums ranges from 7 to 9 million acres, and the yield averages 11 to 15 bushels an acre. Ordinarily, somewhat more than half the acreage is harvested for grain, the remainder being used as forage. The average annual output of grain from grain sorghums for the 10-year period 1927-36 amounted to about 86.2 million bushels. In 1938 the crop increased sharply, production being around 99 million bushels. Production in 1939 dropped to about 83 million bushels. Texas is by far the largest producing State, the annual harvest averaging more than 50 million bushels. Oklahoma, Kansas, New Mexico, California, and Colorado rank next in importance.

Grain sorghums are used almost exclusively for animal feed, and are fed chiefly on the farm. They are regarded as an essential ingredient of scratch feeds for poultry. The proximate composition of the grain is similar to that of corn (maize), except that the oil content is somewhat lower. This would indicate that sorghum grain might be used for the production of starch, edible oil, and certain byproduct feeds, just as corn is now used. The germ of the sorghum grain constitutes 10 percent of the kernel by weight, and contains more than 30 percent of oil, being in that respect very similar to the germ of corn.

RICE

Rice is a sectional crop, 80 percent of its production being confined to the States of Louisiana, Texas, and Arkansas. Most of the remainder is grown in California. Acreage planted to rice has passed the million-acre mark 9 times in the past 20 years, but the average planting is somewhat over 900,000 acres. Production for the 10-year period 1928-37 averaged about 43.4 million bushels of rough rice, with an average annual farm value of 32 million dollars. Production for 1938 was 52.5 million bushels, and for 1939, about 52.3 million bushels. The cash farm income from rice was about 34 million dollars in 1938 and about 33 million dollars in 1939.

Of the total rice crop produced, from 1.8 to 2.6 million bushels are used for seed. From 700,000 to 800,000 bushels are used on the farm for food and as feed for livestock, principally in Louisiana where commercial rice growing developed from small home plantings.

Rice growing was introduced into the American colonies about 1690, and as early as 1712 South Carolina exported 3 million pounds of cleaned rice. Rice was imported into the United States for the first time in 1861. It was not until the changed conditions in southern agriculture which followed the Civil War that the center of rice production moved westward to the Gulf coast and lower Mississippi valley. Rice culture was not introduced in California until 1912.

United States production of rice is only about 1 percent of world production, not including China, but even so the United States ranks eighth among rice growing countries. Less than 60 percent of the crop is consumed in continental United States. About 25 percent is shipped to our outlying possessions, Alaska, Hawaii, and Puerto Rico, and 17 percent is exported to foreign countries. In 1931, imports fell below 1 million bushels for the first time in at least 50 years. The largest importation in that period was 16.4 million bushels in 1917. Only twice since 1917 have imports exceeded exports, the net balance in our favor averaging around 7.5 million bushels annually.

Rice, like wheat, is used primarily as a food grain. According to the Biennial Census of Manufactures, 1937, 42,867,252 bushels of rough rice were milled in the United States in that year, the milling products and byproducts being as follows:

Clean Rice:	
Total pounds	1,305,093,791
Total value	$43,414,104
Whole-grain grades:	
Total pounds	1,018,599,295
Total value	$36,435,232
Polished:	
Pounds	1,009,342,492
Value	$36,128,599
Brown:	
Pounds	9,256,803
Value	$306,623

Clean Rice (Continued):	
Second head:	
Pounds	75,913,449
Value	$1,983,506
Screenings:	
Pounds	100,657,440
Value	$2,403,596
Brewers:	
Pounds	109,923,607
Value	$2,591,780
Polish:	
Pounds	32,905,377
Value	$499,709
Bran:	
Pounds	180,875,320
Value	$2,182,560
Other products, value 1/	$756,383

1/ Poultry feed, rice flour, hulls, etc.

Whole grain and second head rice are marketed for food use, a comparatively small quantity being further processed for breakfast foods or cereal beverages. Broken grain, or brewer's rice, is used, as the name indicates, in the brewing industry. As a feed, brewer's rice has practically the same value as corn. Screenings are used mainly as poultry feed. Rice polish and bran are high grade feeds, used mostly in mixed feeds for dairy cattle, or in fattening rations for meat animals. Rice polish has also become a source material for commercial vitamin concentrates.

In the milling of rice, from 20 to 30 percent of the output is rice hulls. This is a low grade byproduct, and is usually run under the boilers at the mill, except in cities where its use as fuel is prohibited by law. The ash content of the hulls is very high, approximately 19 percent, and at least 95 percent of this is silica, hence the fertilizer as well as the feeding value is very low. Even when burned as fuel, the disposal of large quantities of ash is a problem in itself. The hulls have considerable resiliency, even under pressure, and on this account they are used to some extent as packing material. When properly used, the hulls have a good binding quality, and both hulls and hull ash have been used as fillers in concrete and to loosen heavy soils. A process has been developed in Italy for utilizing the silica of the ash in the manufacture of glass. However, no large scale use has been developed for this byproduct, concentrated at mills of various sizes over comparatively limited areas, and totaling more than 200,000 tons annually.

In common with other cereal grains, increasing production means increasing amounts of rice straw, for which some means of disposal must be found. Using a straw-to-grain ratio of 1 : 1 for California and Louisiana production, and 1.5 : 1.0 for Arkansas and Texas production, the average production of rice straw in the 10-year period 1928-37 was just

over a million tons annually, and for the large crops of 1938 and 1939, straw production has increased to around 1.4 million tons.

Rice straw is only slightly less nutritious than oat and barley straws, and it is used to some extent for feed and for bedding down stock on the farm. Small farms in the older rice producing areas probably find its disposal no problem. But to growers on larger mechanized farms, a well established outlet for rice straw would mean at least a small cash return on from 800,000 to a million tons of straw that would at least help to pay its own cost of production. Rice straw is a potential source of raw material for the manufacture of cellulose and paper pulp. In fact, paper and fiber board have been made from this straw.

RYE

United States production of rye is about 2.3 percent of world production. Russia, Germany, and Poland together produce at least 75 percent of the world rye crop.

Rye is grown mainly in the North Central States and in Pennsylvania. From 2 to 4 million acres are planted annually, yielding 17 to 58 million bushels of grain, with a farm value of 12 to 34 million dollars. The cash farm income from rye was about 20 million dollars in 1937. In the following 2 years, however, this amount was reduced by more than half, being about 8 million in 1938 and around 9 million in 1939.

Rye is utilized in the food, feed, and alcoholic beverage industries. According to the Biennial Census of Manufactures, the quantity of rye milled and of flour produced has decreased steadily for the past 10 or 12 years, that is, from 9.6 million bushels milled and 1.6 million barrels of flour produced in 1929 to 8.6 million bushels milled and 1.4 million barrels of flour produced in 1937. Milling byproducts--bran, screenings, and shrivelled grains--are used in mixed feeds, and an unknown quantity of grain is fed on the farms where grown. Rye is also used in cereal beverages, coffee substitutes, and other cereal preparations, but statistical data are not available. According to data issued by the U. S. Treasury Department, about 5.5 million bushels of rye was used in the year ending June 30, 1939, in the production of distilled liquors and ethyl alcohol. Rye has been used commercially in place of corn for the manufacture of butyl alcohol and acetone, when the price differential was in its favor. Dried distiller's grains and concentrated distiller's slop are utilized by the mixed feed industry.

Exports of rye, which ranged from 10 to 50 million bushels in the 15-year period 1914-28, dwindled to less than 500 bushels in 1934, due to increasing stability in the European agricultural situation. In 1937, exports jumped to over 6.5 million bushels.

For the most part, rye is grown in the same areas that produce wheat, and rye straw can be used for the same purposes as wheat straw, that is, for bedding stock on the farm and for industrial purposes off the farm, such as the manufacture of straw board and paper pulp. According to estimates of the Bureau of Plant Industry, the ratio of rye straw to grain is 2.5 : 1.0. This means that the average production of rye straw for the 10-year period 1928-37 was something over 2.5 million tons annually, and for 1938 was more than 3.8 million tons. Assuming that 25 percent of the straw produced may be used advantageously on the farm, and that the remainder would be available for industrial utilization, almost 2 million tons, on an average, are available for industrial use, and in years of high production, such as 1935 and 1938, the figure may be pushed up to 3 million tons or more. Even figures like these are insignificant when compared with the huge quantities of wheat straw, corn stover and cobs, and cotton stems and pods potentially available each year. At the present time, almost 98 percent of the 6.7 million tons of paper pulp produced in the United States is wood pulp. Less than 150,000

tons were produced from "all other sources," according to the Biennial Census of Manufactures for 1937. Those other sources are listed as "principally cottonseed-hull fiber pulp, cotton linter pulp, rag pulp, reclaimed paper, and straw pulp."

Rye straw, like other cereal straws, is a potential source of raw material for the manufacture of cellulose and paper pulp. It is probable that a very small quantity of this straw is now used with wheat straw in the manufacture of paper and fiber board.

COTTON

Cotton is the greatest cash crop of the United States. It has also been for many years our most important export crop. The region of production--the Cotton Belt--extends broadly from the Carolinas westward through the greater part of Texas and Oklahoma. Considerable quantities are grown under irrigation in California, New Mexico, and Arizona, but normally such quantities are small in proportion to that grown in the main part of the Cotton Belt.

Over the last 25 years this country has harvested from about 24.2 (1938) to 44.6 (1926) million acres of cotton. The crop during this period has ranged from about 7.9 million (1921) to about 18.9 million bales (1937). The standard bale weighs 500 pounds gross or 478 pounds net. The annual production for 1938 and 1939 was about 11.9 million and 11.8 million bales, respectively.

The farm value of cotton in 1919 was about 2 billion dollars, based on the season average price per pound of 35.41 cents received by farmers, the highest price per pound on record. In 1931 the farm value was only about 484 million dollars, based on an average of only 5.66 cents per pound, the lowest average price per pound since 1894. The farm value in 1938 was approximately 515 million dollars, based on an average of 8.59 cents a pound received by farmers. The cash income received by farmers from the sale of lint cotton was approximately 770 million dollars during the calendar year 1937 and about 576 million dollars in 1938.

Texas is the leading producing State, with an average annual output for the 10-year period 1928-37 of about 4.1 million bales.

Normally, more than half of the lint cotton produced in the United States is exported. An idea of the annual size and trend of this export trade may be given briefly. In the season beginning August 1, 1920, 5.7 million running bales were exported; season beginning August 1, 1926, a record high of 10.9 million; season beginning August 1, 1930, 6.8 million; season beginning August 1, 1935, 6.0 million; season beginning August 1, 1937, 5.6 million; and in the season beginning August 1, 1938, only 3.3 million running bales were exported. The running bale is the bale as it leaves the gin press. For the 10-year period 1930-39, the average gross weight of a running bale of cotton was 512.4 pounds, ranging from 506 to 519 pounds. The average net weight during this period was 490.4 pounds.

For the last 10 years the annual consumption of cotton in the United States has varied from a little less than 5 million running bales for the year beginning August 1, 1931, to almost 8 million bales in the year beginning August 1, 1937. During the next 2 seasons the cotton consumed in this country was about 5.7 million and 6.9 million running bales, respectively.

In recent years, an average of only about 60 percent of the cotton fabrics produced is going into clothing and household furnishings, while what are called "industrial" uses account for the remaining 40 percent.

The total production of cotton linters for the season ending July 31, 1938, was about 1.5 million running bales, and for the season ending July 31, 1939, the production was approximately 1.1 million running bales. The domestic consumption of linters during the former period was about 715,000 running bales and during the latter season the consumption was approximately 851,000 running bales.

Large quantities of cotton linters are used in making batting, wadding, mattress felts, and other padding materials. A small quantity is used in making paper. Of the three commercial types of rayon produced in this country, acetate and cuprammonium are manufactured from cotton linters, while viscose is now prepared almost entirely from wood pulp. Linters are also used in making nitrocellulose for explosives, celluloid, photographic films, lacquers, etc. In recent years increasingly larger proportions of the domestic supply of linters have been exported. During the year beginning August 1, 1930, about 112,000 running bales were exported; during the year 1936-37 the exports amounted to about 270,000 running bales; during the year 1937-38 approximately 275,000 running bales were exported. However, during the year 1938-39 the exports dropped to about 213,000 running bales.

In 1926 about 6.3 million tons of cottonseed was crushed. About 1,887 million pounds of oil and about 2.8 million tons of meal were produced. The production of cottonseed for the crop year August 1, 1938, to July 31, 1939, totaled about 5.3 million tons, of which approximately 4.5 million tons was crushed. The remaining seed was retained by farmers for planting, for use as feed for livestock, or as fertilizer. From the 4.5 million tons of cottonseed crushed, about 1,409 million pounds of crude cottonseed oil was produced. In the calendar year 1938 domestic production of crude cottonseed oil amounted to about 1,678 million pounds. The cash farm income from cottonseed was about 113 million dollars in the calendar year 1937, about 85 million in 1938, and around 83 million in 1939.

Between 1931 and 1938 the total annual factory consumption of cottonseed oil ranged from about 1,084 million pounds in 1932 to about 1,687 million pounds in 1937. In 1938 the factory consumption was approximately 1,540 million pounds, distributed by classes of products as follows:

	1,000 lbs.
Compounds and vegetable cooking fats	1,051,347
Oleomargarine	142,857
Other edible products	198,155
Soap	2,883
Paint and varnish	184
Printing ink	168
Miscellaneous	2,971
Foots and loss	141,425
Total factory consumption	1,539,990
Total apparent disappearance	1,658,406

These figures show that more than 90 percent of the factory consumption of cottonseed oil in the United States is used for edible products, particularly for shortenings.

Besides oil and linters, cottonseed furnishes oil cake or meal, and hulls. The production of cottonseed cake and meal for the year beginning August 1, 1937, was about 2.8 million tons, compared with about 2.0 million tons for the year beginning August 1, 1938. The production of cottonseed hulls was about 1.6 million tons for the former period and about 1.2 million tons for the latter period.

Cottonseed cake or meal is used almost exclusively for stock feeding and for fertilizer. The quantity of meal used as a fertilizer on cotton farms in 1938 and 1939 was approximately 203,000 tons and 93,000 tons, respectively, compared with the annual average for the 10-year period 1927-36, of about 196,000 tons. The largest quantity used on cotton farms was in 1932, when it amounted to about 465,000 tons. There is no official estimate on the quantity of cottonseed meal used as feed. It is estimated that for the year beginning July 1, 1939, the supply of cottonseed cake and meal available for domestic use will be around 1.9 million tons. Cottonseed hulls are used as a filler in stock feeds, as a packing and stuffing material, as a fertilizer, and as fuel at the crushing plants. Information on the quantities used for these, or other purposes, is not available.

Cottonseed flour is a food item of some importance, especially in some of the southern States. Industrial uses are also being developed on an experimental basis.

FLAX

Flax will grow over most of the United States, but its commercial production is limited mostly to the North Central States and the Pacific Coast. There are two distinct types of flax grown in this country. Fiber flax is a tall, nonbranching variety, grown mostly in Oregon, and seed flax is a short, much branched type, grown principally in Minnesota, the Dakotas, Kansas, and California.

Fiber flax.--An average annual production of only about 420 tons of raw spinning flax fiber was produced in the United States in the 8-year period 1930-37. In 1938 the production was about 350 tons. Oregon produces practically all of the commercial domestic fiber flax. The acreage in Oregon since 1931 has ranged from about 700 acres in 1933 to about 4,300 acres in 1938. About 4,000 acres of fiber flax was grown in 1939. The average yield of flax in Oregon is about 1.65 tons per acre. From this are obtained 230 to 300 pounds of linen fiber and 100 to 130 pounds of tow and pullings ready for spinning.

The Oregon linen fiber is of good quality and is used mainly for sack twine, fish lines and nets, and shoe and sewing thread.

In the fiber flax industry, the seeds not saved for planting the next year's crop are a byproduct, disposed of by sale to oil mills. The shives, or hard, woody material separated from the fibers, are used for fuel at the processing plants.

Seed flax.--Flax grown for seed (linseed) is an important cash crop in Minnesota and North Dakota. It is also grown in South Dakota, California, Montana, Kansas, and several other States. It is not a surplus crop. Importations exceed domestic production. The peak of all-time domestic production was reached in 1924, when about 31.2 million bushels was produced with a farm value of about 68 million dollars. In recent years drought and insects have reduced production drastically in the principal flaxseed-producing area. Wilt and rust cause extensive losses especially in localities where recently developed resistant strains are not planted.

The average annual production of flaxseed in the 10-year period 1928-37 was about 11.9 million bushels, ranging from about 19.1 million bushels in 1928, with a farm value of about 37 million dollars, to as low as about 5.3 million bushels in 1936, with a farm value of only about 10 million dollars. In 1938 the production was approximately 8.2 million bushels, and in 1939 the production was increased to about 20.3 million bushels. The cash income to farmers from the sale of flaxseed in 1938 and 1939 was around 12 million and 24 million dollars, respectively.

For the 10-year period 1928-37, the average annual acreage of flaxseed harvested was about 2 million acres. In 1938 and 1939 the acreage harvested was about 936,000 and 2.3 million, respectively.

The domestic supply of flaxseed has fallen to as low as 25 percent of domestic consumption. This decrease in domestic production has led to increased importations of foreign flaxseed and linseed oil and to the use of substitute oils. Imports of flaxseed during the past 10 years have ranged from a low of about 6.2 million bushels in the year ending June 30, 1933, to about 26 million bushels in the year ending June 1937. The importation during the year ending June 1939 was nearly 19 million bushels.

Flaxseed is processed exclusively for linseed oil, which is the principal drying oil used by the paint and varnish industry. The amount of flaxseed crushed annually in the United States in the past 10 years ranged from about 17.4 million bushels in the crop year 1932-33 to about 35.5 million bushels in 1929-30. For the crop year beginning July 1, 1938, the crushings amounted to approximately 25.6 million bushels. The linseed oil produced in this same period ranged from about 318.1 million pounds in 1932-33 to about 651.0 million pounds in 1929-30. For the crop year beginning July 1, 1938, the oil produced amounted to about 501.5 million pounds.

The annual factory consumption of linseed oil in this country between 1931 and 1938 ranged from about 220 million pounds in 1932 to about 325 million pounds in 1937. In 1938 the factory consumption of linseed oil in the United States by classes of products was:

	1,000 lbs.
Paint and varnish	216,568
Linoleum and oilcloth	55,395
Printing inks	16,804
Soap	1,455
Compounds and vegetable fats	6
Miscellaneous	8,253
Total factory consumption	298,481
Total apparent disappearance	489,544

These figures show that in 1938 the paint and varnish industry in the United States consumed about 73 percent of the total factory consumption of linseed oil, and the linoleum and oilcloth industry consumed about 19 percent.

Linseed press cake or meal is used primarily as a high-protein feed for livestock. In 1937 the production of linseed cake and meal totaled nearly 625,000 tons. It is estimated that for the year beginning July 1, 1939, the supply of linseed cake and meal available for domestic use will be about 360,000 tons, compared with about 246,000 tons in 1938-39.

The flax straw from the seed crop is mainly a waste product, the amount available varying directly with the quantity of flaxseed produced.

It is estimated that over 1 million tons of dry flax straw is produced annually in the flaxseed-growing area of the United States. The crude bast fiber content of the straw ranges up to about 20 percent. The remainder is shives, for which no industrial use has been developed. Flax straw has been used in making insulation board, and it is a potential source of raw material for the manufacture of cellulose and paper pulp. Lately interest has developed in making cigarette paper from flax straw. Small quantities of flax straw are now used commercially in the manufacture of upholstery tow. There is also a well-developed industry based on the manufacture of flax straw rugs.

PEANUTS

Peanuts are grown in all of the Southern States. The average annual production (picked and threshed) during the 10-year period 1928-37 was about 990 million pounds. In 1938 the amount picked and threshed was about 1,306 million pounds and in 1939 about 1,180 million pounds. The average annual acreage harvested (picked and threshed) in the 10-year period 1928-37 was about 1.4 million, compared with about 1.7 million in 1938 and about 1.9 million acres in 1939. Of the total acreage planted to peanuts, which includes approximately one-half of the interplanted acres, more than 60 percent is "hogged off," or used as forage.

The cash income received by farmers from the sale of peanuts in 1937 was about 38 million dollars, and in 1938 and 1939 around 45 million and 34 million dollars, respectively.

Farmers' stock peanuts consumed by mills in 1938 in the production of cleaned and shelled peanuts and crude peanut oil amounted to approximately 1,100 million pounds. It has been estimated unofficially that about 35 percent of this amount was made into peanut butter and about 25 percent into peanut oil, and that about 20 percent was used in confectionery. Salted peanuts and peanuts roasted in the shell accounted for the remainder (about 20 percent).

In the crop year beginning October 1938, the amount of peanuts crushed in the United States was about 204.2 million pounds on the shelled basis. For the same period about 85.1 million pounds of crude and virgin peanut oil was produced. The shelled nuts yield approximately 35 percent oil and 65 percent cake or meal.

In 1938 the factory consumption of peanut oil was about 62.5 million pounds. Of this amount approximately 85 percent was used for the manufacture of shortening, and about 9 percent was used in the manufacture of oleomargarine and other edible products. A small quantity (about one percent) was used in soap.

The meal is used almost entirely as a high-protein feed for livestock. Many of the hulls are burned in the oil mills, some are used as a diluent in feeds and fertilizers. Peanut vines have some value as a feed and are used to some extent for this purpose. They are also plowed under for humus.

It has been demonstrated that many products can be made from peanuts. Some which have received publicity are breakfast foods, high-protein flour, vegetable milk, ice cream powders, stock feeds in various combinations, dyes, inks, cosmetics, and medicinals.

It is estimated that the annual production of peanut hulls is around 183,000 tons on the dry basis, of which about 92,000 tons are available for industrial use. They are a potential source of raw material for the manufacture of xylose, cellulose, and paper pulp.

SOYBEANS

Cultivation of soybeans as a soil-improvement, hay, or cash seed crop has become increasingly important to American agriculture, especially during the last 10 years. Production of beans increased from about 2.3 million bushels in 1917 to about 6.9 million bushels in 1927, and to about 62.7 and 87.4 million bushels in 1938 and 1939, respectively. In 1927 the farm value of the beans was less than 15 million dollars, based on the season average price per bushel of $1.83 received by farmers. In 1938, however, the farm value increased to nearly 45 million dollars, based on an average price of only 76 cents per bushel. The cash farm income from soybeans for 1939 has been estimated at 49.6 million dollars, an increase over the previous year of almost 54 percent.

In 1917 less than 500,000 acres were devoted to the growing of soybeans for all purposes. In 1927, the number of acres was about 2.4 million, and in 1937 the acreage increased to about 7 million. In 1938 and 1939 the total acreages were approximately 8.2 and 10 million acres, respectively. Of the 10 million acres planted in soybeans in 1939, about 4.2 million were harvested for beans, about 4.4 million were harvested for hay, and about 1.4 million acres were grazed or plowed under.

The production of soybeans, for beans, in the six commercial States, Ohio, Indiana, Illinois, Iowa, Missouri, and North Carolina, was about 82.3 million bushels in 1939 compared with about 58.8 million in 1938, and about 42.4 million in 1937. The annual average for the 10-year period 1928-37 was about 20.1 million bushels. Illinois produced nearly 60 percent of this quantity.

In 1938 about 2 million bushels of soybeans and the equivalent of about 500,000 bushels of beans in the form of oil were exported from the United States.

The production of soybean oil in the United States has kept pace with that of soybeans. The amount of beans crushed during the season 1927-28 was about 558,000 bushels; in 1936-37 the amount increased to approximately 20.6 million; during the season 1937-38 it reached about 30.3 million bushels; and in 1938-39 the amount crushed reached the record high of about 44.5 million bushels. During the same periods, excepting 1938-39 for which figures are not yet available, the amounts of soybean oil produced were approximately 4.4, 183.7, and 279.3 million pounds, respectively.

The processing of soybeans is carried out principally by two methods, namely, pressing and solvent extraction. In either case the beans are cracked, flaked, and conditioned with respect to moisture and temperature prior to the separation of the oil.

The factory consumption of soybean oil in 1931 was about 28 million pounds; in 1937 it was about 179 million; and in 1938 it rose to about 237 million pounds, distributed by classes of products as follows:

	1,000 lbs.
Compounds and vegetable cooking fats	137,133
Oleomargarine	39,885
Other edible products	11,280
Soap	10,897
Paint and varnish	15,183
Linoleum and oilcloth	3,605
Printing ink	59
Miscellaneous	5,340
Foots and loss	14,046
Total factory consumption	237,428
Total apparent disappearance	305,395

These figures show that approximately 80 percent of the factory consumption of soybean oil in 1938 was used in edible products.

Soybean cake or meal, the product remaining after the oil has been extracted, is used mainly as a stock feed. It is estimated that approximately 1,050,000 tons of soybean meal, equivalent to about 44 million bushels of crushed soybeans, were produced in the United States in 1938, and that for the year beginning July 1, 1939, the supply of soybean cake and meal available for domestic use will be about 1.4 million tons, compared with about 732,000 tons in 1937-38.

Soybeans contain little or no starch. Carbohydrates are present in the meal in the form of crystallizable sugars, to the extent of 10 to 15 percent. The high protein content of the meal, from 40 to 45 percent, makes it especially valuable for industrial uses.

A number of industrial products have been developed from soybean meal, including adhesives and molded plastics. As a plastic, it is used in the automobile and electrical appliance industries. The meal is also used in small quantities in various food products.

CASTOR BEANS

In the last quarter of the 19th century considerable quantities of castor beans were grown in Kansas, Oklahoma, and other Midwestern States. The maximum production in Kansas occurred in 1879, when 68,170 acres produced 766,143 bushels of castor beans valued at $1.00 per bushel. During the period 1876 to 1916 the returns to Kansas growers ranged from $0.83 to $1.72 per bushel. Production of this crop constantly declined and almost disappeared from American agriculture during the first decade of the present century. As a result of the demand during the World War for castor oil as an aircraft lubricant, several thousand tons of seed were produced in the Southern States, but since then and until very recently little effort has been made to reestablish this crop on a sound agricultural and economic basis.

Practically the entire production of castor oil is derived from imported beans. In 1936, 164 million pounds of castor beans were imported; in 1937, about 147 million pounds; and in 1938, about 114 million pounds.

In 1936, the castor beans crushed in this country amounted to about 138 million pounds, in 1937 to about 146 million, and in 1938 to about 115 million pounds. The production of oil in these years approximated 64.6, 69.0, and 52.3 million pounds, respectively.

The factory consumption of castor oil in this country between 1931 and 1938 ranged from about 14.7 million pounds in 1932 to approximately 34.8 million pounds in 1937. In 1938 the factory consumption was about 28.2 million pounds, distributed as follows:

	1,000 lbs.
Soap	1,810
Paint and varnish	5,283
Linoleum and oilcloth	1,313
Printing ink	200
Miscellaneous[1/]	19,554
Total factory consumption	28,160
Total apparent disappearance	53,148

1/ Miscellaneous consumption includes uses in drugs and cosmetics, in lubricants, in lacquers and plastics, in textile finishing, and in various other industries.

TUNG NUTS

Tung nuts were first planted in the United States between 1900 and 1905. One of the earliest successful small planting was made at Gainesville, Florida. Since about 1923, commercial plantings have gradually increased and at the present time there are probably over 150,000 acres under cultivation. Mississippi has the most extensive planting, but Florida, Louisiana, Alabama, Georgia, and the Gulf coast region of Texas also have large plantings.

Tung oil, which is obtained from the nuts of the tung-oil or China-wood-oil tree, ranks second only to linseed oil in the drying-oil industry.

Domestic commercial production of tung oil started in 1932, when two full tank cars were shipped from Gainesville, Florida. In 1934 approximately 400,000 pounds of tung oil were produced in Florida and Louisiana from tung nuts grown in the Gulf States. In 1936 about 2 million pounds of oil were produced and processed in the South. The 1938 crop yielded about 4 million pounds of oil. Complete production data from the 1939 nut crop are not available at this writing, but the figures given indicate the rapid growth of this new industry.

American tung oil is generally superior to that produced in China, and has commanded a premium of from 2 to 4 cents a pound over the Chinese product. However, the United States is still dependent upon the Orient for its principal supply of tung oil. Imports since 1909 have ranged from about 33.3 million pounds for the crop year beginning July 1920, to almost 150 million pounds for the crop year beginning July 1935.

Tung oil is used mostly in paints and varnishes. Substantial quantities are also used in the manufacture of linoleum and oilcloth. In quick drying varnishes it may be mixed with linseed or perilla oils. It is one of the very few vegetable oils that cannot be used in food products, because of its aperient properties.

LEMONS

The domestic commercial lemon crop is confined entirely to the State of California, where production has more than doubled in the past 20 years. Average production for the 5-year period 1919-23 was approximately 4.8 million boxes, and for the 5-year period 1933-37 it was 8.5 million boxes. Since only two-thirds of the lemon trees were in full bearing in 1937, production may be expected to increase for a number of years. Average annual production during the next 5-year period will probably be about 10.5 million boxes. The 1938 production of 11.32 million boxes exceeds the previous record of 1934 by over a million boxes, due to the combined effect of a good season and the coming into heavier bearing of young orchards. In 1939 production was 10.65 million boxes.

Production varies widely from year to year due to weather conditions in the growing areas, and demand for fresh lemons is also dependent on weather conditions in consuming areas. When seasons of high production and low demand coincide, as much as 75,000 tons of lemons may be diverted to byproducts use.

Coincident with increased production, United States imports of lemons have declined from an average of 1.25 million boxes in the 5-year period 1921-25 to an average of 45,000 boxes in the 1933-37 period. For these same 5-year periods annual exports averaged 205,000 and 477,000 boxes, respectively. That is, exports have more than doubled in the last 15 or 20 years, and imports have dropped even more rapidly. Canada is the principal outlet for American lemons, although small quantities are exported to other nearby countries and to the Far East.

The results accomplished by the California lemon cooperative organization constitute an effective demonstration of what can be done toward economic stabilization of a food crop by a well organized plan for industrial utilization of culls and surplus. According to published reports, during the first 17 years of its existence the Exchange Lemon Products Company, which is a subsidiary of the California Fruit Growers Exchange, handled 16.8 percent of the lemons produced, a total of slightly less than 500,000 tons, with returns to the growers slightly in excess of 5 million dollars. While the largest, this is not the only plant in California that is processing lemons.

The principal lemon products are citric acid, lemon oil, pectin, and juice. While adequate figures are not available, the statement has been made that the Exchange Lemon Products Company is the largest single producer in the world of lemon oil and citrus pectin, and supplies one-fourth of this country's entire requirements of citric acid. Canned lemon juice is a comparatively recent development. Total production has steadily increased from 100,000 cases in 1935 to 425,000 in 1938. Lemon juice differs from the other citrus juices in that it must be diluted for beverage use, and finds a more extended use in various mixed and carbonated drinks and in cooking. Concentrated juice, beverage base, and juice powder are also produced. Production

of lemon oil is probably from 150,000 to 200,000 pounds annually. Residues at the byproducts plants are dehydrated for use as feed or fertilizer.

It has been estimated that lemon products find some 80 uses in the industrial field, in food products, medicinals and cosmetics, in photography, printing, and dyeing, and as intermediates in various scientific and technical processes.

Imports of lemon oil have dropped from an average of 471,000 pounds for the 5-year period 1926-30 and 210,000 pounds for the 1931-35 period to 89,000 pounds in 1937. Around a million pounds of lemon peel (crude, dried, or brined) are imported annually, and also somewhat less than 200,000 pounds of prepared peel. Figures for domestic production of peel products are not available. There are small and varying exports of citric acid, pectin, and oil. Unsettled trade conditions are especially disastrous to newly developing trade outlets.

ORANGES

California and Florida together produce about 97 percent of our total orange crop. The production of oranges has more than doubled in the last 20 years. Of the bearing trees in the groves of California, Florida, Texas, and Arizona in 1938, estimated at around 37.8 million, nearly half are less than 15 years old, and a fourth are from 5 to 10 years old. With this large proportion of young trees yet to come into full bearing, it is considered likely that annual production during the next 5 years (1940-44), will average 75 million boxes or more, as against an average annual output during the last 5 years (1935-39) of around 68 million boxes. Most of the increase will be in Valencias and other late varieties. The farm value of oranges for the period 1930-38 has ranged from 39.5 million dollars in 1932 to 85.9 million dollars in 1936.

As i the case with most of the fruit crops, oranges are raised primarily for the fresh fruit market. Provision must be made, however, for disposal of cull and surplus fruit. Important quantities of oranges have been utilized for the manufacture of orange juice, orange concentrate, canned oranges, marmalade, candied peel, and similar food products during recent years. Approximate quantities diverted to these uses are indicated in table 5.

Table 5.- Quantity of oranges canned or used for concentrates, marmalade, etc., from 1934 to 1937

Season	California and Arizona	Florida	Total
	1,000 boxes	1,000 boxes	1,000 boxes
1934-35	3,690	178	3,868
1935-36	1,727	213	1,940
1936-37	5,872	620	6,492
1937-38	4,247	1,250	5,497

According to the Biennial Census of Manufactures, 1937, the orange juice pack for that year was 1,646,059 cases, and in addition, 859,361 gallons in bulk. Corresponding figures for 1935 were 959,235 cases plus 1,091,662 gallons. The 1938 orange juice pack was approximately 1.3 million cases, with no estimate on the bulk pack available at this writing. In addition, under usual conditions from 90,000 to 110,000 pounds of orange oil are marketed annually. This diversification of use not only helps to stabilize prices for fresh fruit but brings added returns to growers. According to its latest annual report a large California cooperative has returned to producers, over the last 12 years, a total of 3.3 million dollars received from orange byproducts. This includes returns not only from juice, concentrates and oil, but from orange meal, the dehydrated residue from these products, which finds a ready market as a feed for dairy cattle.

GRAPEFRUIT

World production of grapefruit has increased at a tremendous rate during the past 20 years, largely because of a seven-fold expansion in the United States. This country has always led in grapefruit production, and in 1937 we produced 90 percent of the world crop.

The number of bearing grapefruit trees is five times as large now as it was in 1920. There are some 13,100,000 trees in bearing, of which about two-thirds have not reached full production. It is considered likely that the present bearing acreage will permit an average production during the next 5 years (1940-44) of 35 million boxes, as against an average annual production during the last 5 years (1935-39) of around 32 million boxes. Judging from past relationship of supply and prices, this yearly output of grapefruit may mean decidedly low prices to growers. The farm value of grapefruit for the period 1930-38 has ranged from about 7.4 million dollars in 1932 to about 14.7 million in 1936.

Large increases in the production of grapefruit may be expected, especially in Texas and Arizona, where over 90 percent of the trees have not yet reached full bearing. The same is true of California, where about 70 percent of the bearing trees are young. In Florida, on the other hand, nearly two-thirds of the trees have reached full production, and there is not likely to be so great an increase in this State. The western areas are growing mostly seedless grapefruit, whereas Florida produces most of the seeded fruit.

Increasing quantities of grapefruit hearts and juice have been canned in recent years. Thus, a million cases of grapefruit sections were canned in 1928-29, and this item had grown to 4.1 million cases in 1936-37. The canning of grapefruit juice increased from 205,000 cases (packed in Florida) in 1928-29 to 8.8 million cases in 1937-38. Texas began packing juice in 1935, and in the 1937-38 season the Texas juice pack was over 5 million cases, almost equalling the combined Florida-Texas pack of 1936-37. The Texas-Florida grapefruit juice pack for 1938-39, the largest on record, was estimated as approximately 11 million cases, about the same as the total juice and segment pack for 1937-38.

These figures are given in cases of all sizes, and do not include juice shipped in bulk. The Biennial Census of Manufactures, 1937, gives the 1935 bulk pack of grapefruit juice as 692,352 gallons, and the 1937 pack as 218,686 gallons. Later data are not available.

It has been estimated that 40 percent or more of the total output of Florida and Texas grapefruit is utilized in the canning of juice and sections. This means a tremendous and rapidly increasing accumulation of cannery waste. Disposal of liquid effluent is the most pressing problem, from the point of view of sanitation. Special

methods of neutralizing and denaturing are being developed, so that the material can be handled by sewage disposal plants. While pressing need demands immediate action, this is probably an extremely wasteful practice. Methods will undoubtedly be developed for salvaging and utilizing important organic materials in solution or suspension in this highly putrescent material which is now worse than useless on account of the nuisance problem it creates. The solid wastes, consisting of skin, rag, and peel, are being salvaged to some extent. The essential oil from the peel has possibilities in the flavoring field. Grapefruit seed oil is being produced on a commercial scale in Florida. About 10 tons of wet seed yield 1 ton of oil. The small output of the one plant operating is in demand in the textile industry. Raw material for several similar plants is available, and it is believed that a market at remunerative prices can be found for all of the grapefruit seed oil that may be produced.

The glycocide naringin, which gives grapefruit its characteristic bitter flavor, can be recovered at juice plants. It has a potential value in beverage manufacture and medicinals. Dried and candied peel and marmalade are produced, but the market is limited.

The biggest outlet for the solid wastes is in the form of a dried and ground product for use in dairy feeds. The waste liquor from the drying plants has been used experimentally as a substrate for the production of lactic and citric acids by controlled fermentation, but for the most part it is handled as sewage waste.

APPLES

The chief apple-producing States are Washington, which in recent years has produced an average of 31 million bushels annually; New York, 17 million bushels; and Virginia, 12 million bushels; followed by Pennsylvania, California, and Michigan. Of a total average annual apple crop estimated at 150 million bushels, about 90 million bushels represent the average commercial or market crop, produced in the commercial type of orchard. The apples from these orchards make up the real supply in the channels of trade, although in some years rather large quantities of apples produced in farm home orchards are sold fresh.

The number of apple trees in the country has been declining for many years, but because the reduction in the number of trees in the last 15 years has been due largely to the removal of poor trees from unprofitable orchards, and because of better care given bearing trees, the actual production of apples has not decreased in proportion to tree removals. For example, in 1935 the total number of trees of bearing age was 28 percent less than in 1920, but total production had declined only 8 percent.

Apple production in the 3-year period 1936-38 has varied tremendously, ranging from 117.5 million bushels in 1936 to 211 million bushels in 1937. The average of these three crops -- 153 million bushels -- is about what can be expected with average growing conditions. 1939 was an exceptionally heavy crop year, the commercial or fresh market crop alone being estimated around 100.3 million bushels. The number of trees and the total production for the three principal apple growing regions, based on averages for the years 1932-36 are shown in table 6.

Table 6.- Apple trees and production by regions, 1932-36 average

Item	Western region	Central region	Eastern region
Production .....million bushels	51.3	31.3	60.7
United States crop.....percent	35.8	21.8	42.4
Bearing trees.....millions	11.6	34.1	36.8
Trees of bearing age...percent	87.8	79.1	84.2
Average yield per bearing tree.....bushels	4.4	.9	1.65

Because of the increase in the use of other table fruits and fruit juices, the apple has met with very serious competition in home markets. The foreign market has also been curtailed.

PEACHES AND APRICOTS

The peach crop ranks third among fruit crops in the United States, peaches being exceeded in farm value only by apples and oranges. For the 10-year period 1928-37, the peach crop averaged 54.2 million bushels. In 1938 production was 51.9 million bushels, and in 1939 production reached a total of 61.7 million bushels, a figure that has been exceeded only 4 times in the past 40 years. These figures include peaches not harvested on account of market conditions, as shown in table 7.

Table 7.--Peaches not harvested on account of market conditions

Crop year	Total	Sold but left on trees
	1,000 bu.	1,000 bu.
1928	3,957	-
1930	10,639	6,180
1931	8,478	3,938
1932	6,733	-
1933	3,571	1,404
1934	2,208	-
1938	1,916	-

Peaches are grown commercially in 40 States, the production ranging from about 18,500 bushels in New Hampshire to 22 million bushels and more in California. Georgia ranks second, with about 5.5 million bushels.

The average annual farm value for the 10-year period 1928-37 was 44.9 million dollars, ranging from 19.5 million dollars in 1932 to 61.3 million in 1929. In 1938 the farm value was around 38.5 million dollars. The farm values given apply only to the harvested portion of the crop, plus that sold but left on the trees.

The bulk of the crop in the Eastern States, mostly of freestones, is grown for the fresh market. There is some commercial canning, and a small development in quick freezing, still in the experimental stage.

California, always the home of the peach-canning industry, has averaged more than 85 percent of the known world pack for the last 5 years. In addition, this State has provided more than 40 percent of the world production of dried peaches.

The clingstone peach has been developed primarily for canning, and comparatively few clings reach the fresh market. Freestone peaches are raised both for market and for drying. Over 60 percent of the freestone peach crop is dried. In recent years the drying of clingstone peaches has been competing with and lowering the market for the freestones. This is partly due to the fact that the clingstones for drying are byproducts or surplus from the canning industry.

As with all tree crops, the problem of disposal in maximum crop years becomes acute. Even in normal years, cull peaches average approximately 17 percent of the total crop. In addition, there is always the problem of waste from canneries and drying yards. Both canned and dried peaches are pitted, andpit waste alone may run as high as 65,000 tons. This material has an appreciable salvage value, the kernels for both volatile and fixed oils and their stony covering for fuel or activated carbon. There are also immense quantities of trimmings, skins, and liquid effluent which are now wasted and whose cost of disposal is an added charge against the final product.

In all probability, 90 to 95 percent of all the apricots grown in this country are produced in California. Other Western States, including Oregon, Washington, Idaho, and Utah, contribute comparatively small quantities. California's average annual production for the 10-year period 1928-37 was about 231,900 tons. The 1937 crop was larger than any preceding, totaling 311,000 tons. In 1938 production dropped to 166,000 tons, but in 1939 there was a record breaking production of 317,000 tons (about 13 million bushels).

Most of the apricot crop is dried or canned, less than 10 percent reaching the fresh market. On the fresh basis about 162,000 tons are dried and 44,000 tons are canned. California supplies the world with dried apricots, 45 to 50 percent of the dried product being shipped abroad, mostly to European countries. From 14 to 24 percent of the canned pack also goes to foreign markets. Apricot pits available for industrial utilization accumulate, according to estimates, at the rate of about 1,380 tons annually.

PLUMS AND PRUNES

All prunes are plums, but not all plums are prunes. A prune may be defined as a plum that will not ferment when dried without removing the pit.

Plums other than prunes have a farm value of around 1.3 to 2.4 million dollars a year. The canned pack averages just under 200,000 cases a year. The industry centers in Michigan and the Pacific Coast States, with New York and other States contributing small amounts.

Prunes are grown almost entirely in the Pacific Coast States. Oregon and Washington raise mostly Italian prunes, while in California the French prune is the chief variety grown. Comparatively few fresh prunes reach the retail market, the great bulk of the prune crop being dried. Both fresh and dried prunes are canned, and the quick freezing of prunes and prune pulp and of prune juice or nectar is a growing industry. The average annual production of 230,000 tons of dried prunes represents about 580,000 tons of fresh prunes with a farm value of about 15 million dollars.

While approximately 600,000 tons of plums and prunes are processed annually, there is comparatively little processing waste, since the canned and dried fruit is neither peeled nor pitted. Problems facing the industry are surpluses in years of maximum production, discards from sorting tables, and nonmerchantable dried fruit.

Due to a decline in exports and to the competition of fresh fruits, canned fruits, and juices, the dried prune market has fallen off until the most serious surplus of the dried fruit industry is in this field.

GRAPES AND RAISINS

Grapes are grown throughout the United States, and there are commercial vineyards in almost every State. By far the most important growing area is in California, followed by western New York and southwestern Michigan.

The only fruit crops outranking grapes in farm value are apples, oranges, and peaches, in the order named. The annual grape crop has averaged over 2 million tons in recent years and represents a cash income of from 40 to 50 million dollars a year. The bearing acreage is at least sufficient to maintain production on the present high level. California raises wine, raisin, and table varieties. Eastern grapes are grown for juice, wine, and fresh market. The California crop averages more than 85 percent of the total. The crop is utilized in the form of table grapes, raisins, juices, canned grapes, and wine.

The surplus problem in the grape industry can often be relieved by diversion of any one type of material to other than its customary uses. For example, raisin grapes are the only varieties canned, and the surplus raisin crop may also be diverted to the production of brandy for the fortification of wine. But when maximum yields occur in the same season in all the principal grape-growing areas, the situation becames acute. There is less opportunity for diversion, the fresh market is clogged, and a chaotic condition develops. Methods of utilization should be developed that will provide an immediate outlet for surplus fresh fruit as well as for greatly augmented quantities of byproducts at canneries, drying fields, juice plants, and wineries.

Probably the largest items in the byproducts list are seeds, stems, and other raisin waste at the drying yards, and pomace, argols, and lees at juice plants and wineries. There are no statistics available on raisin waste. There is a probable annual production of grape pomace of about 185,000 tons. This includes skins, pulp, and seeds, potentially valuable for their content of tannin, pigments, odorous constituents, seed oil, and oil-free seed residue.

The argols and lees from juice plants and wineries are valuable for their content of tartrates, the crude material from which tartaric acid and its salts, including cream of tartar, Rochelle salts, and tartar emetic, are produced. It is estimated by the trade that about 30 percent of the tartaric acid on the market in the United States is used for the manufacture of baking powder.

Importations from wine-producing countries for the 10-year period 1929-38 averaged 18.9 million pounds per year of argols, tartar, and wine lees, and 5.6 million pounds of crude calcium tartrate. These crude materials, valued at almost a million dollars, were admitted duty-free, because they contained less than 90 percent of potassium bitartrate. It would seem that if economically feasible methods for recovery of crude tartrates could be developed, at least a small part of this import trade could be diverted to domestic channels. In addition, in years of maximum production, it should be possible to stabilize the market by diversion

of large quantities of surplus fruit to plants where the crude tartrates and other constituents of commercial value could be extracted and stored for gradual liberation in trade channels. This plan, founded on Federal research and developed over a period of years by cooperative organizations, has proved to be the salvation of the domestic lemon industry.

TREE NUTS

Nut crops are grown commercially in the Southern States and on the Pacific coast.

Cultivation of nuts as a commercial crop began on the Pacific coast with the introduction of almonds and English (Persian) walnuts into California by Spanish settlers. At present, 98 percent of American almonds are grown in California. There have been extensive plantings of walnuts in Oregon in the last 40 years, and commercial plantings of filberts in the Pacific Northwest are even more recent. Pecans are native to the Southern States. Improved varieties have been developed by selection and propagated by budding. Of native nuts not domesticated, black walnuts from the Eastern States and piñon nuts from the Southwest have an established place in retail markets.

In recent years from 10,000 to 20,000 tons of almonds have been produced annually, with a farm value of 2 to 5.5 million dollars. Walnut production in California in recent years has ranged from 30,000 to 50,000 tons annually. The output of improved and seedling pecans has ranged from 20,000 to 50,000 tons. Filberts are grown chiefly in Oregon and Washington. The Oregon output has increased from 60 tons in 1927 to 2,230 tons in 1937, and was about the same in 1938.

The annual production of tree nuts is shown in table 8.

Table 8.--Annual production of tree nuts

Product	Average 1928-37	1938	1939
	Tons	Tons	Tons
Almonds (California)...	12,170	15,000	19,200
Filberts (Oregon and Washington)	1,032	2,240	3,710
Pecans--native and cultivated (12 States)...	32,656	24,860	30,814
Walnuts (California and Oregon).....	42,030	50,800	57,300
Total.....	87,888	92,100	111,024

The production of tree nuts, with the possible exception of wild and seedling pecans, is expected to increase somewhat during the next few years.

Prices to growers fell to low levels in 1930 and 1931. Since then the prices of walnuts and improved pecans have declined somewhat

further. Prices of wild and seedling pecans have remained low, on the average. Almond prices, on the other hand, were high in 1935 and 1936, and even in 1937 when there was a bumper crop they remained well above their depression lows.

Nuts are used primarily for food, either directly or as constituents of pastry, candy, ice cream, or other such delicacies. Most of the research now in progress is directed toward the preparation of the nuts for marketing. There has been no extensive investigation of the economic use of nutshells. Very little is being done on the non-food uses of the nut kernels.

WHITE POTATOES

Potatoes comprise the largest vegetable crop in the United States. During the 10-year period 1928-37, the average yearly production was about 372.3 million bushels. In 1938 and 1939, the total crop was around 374.2 million and 361.0 million bushels, respectively.

Commercial potato production is concentrated in a few well-known areas: Aroostook county, Maine; Long Island, N.Y.; Eastern Shore of Virginia; Red River Valley of Minnesota; and southern Idaho. There are also important growing areas in Michigan, Wisconsin, Colorado, Pennsylvania and the Carolinas. In recent years, the growing of early potatoes has become increasingly important in the South.

The 3.03 million acres harvested in 1939, out of 3.07 million acres planted, compares with 3.02 acres harvested in 1938 and the 10-year average of 3.34 harvested acres. The yield per acre of 119.1 bushels in 1939 was about 4 percent smaller than that of 1938, which was 123.8 bushels per acre, but nearly 7 percent better than the 10-year average of 111.4.

A typical picture of utilization of the crop may be cited from the 1937 figures. The production that year amounted to about 394.1 million bushels. Of this, about 32 million bushels were disposed of as unfit, waste, and feed for livestock; the quantity used as food on farms amounted to 64 million bushels; saved for seed, 32 million bushels; sold, 265 million bushels. The quantity sold in 1937 brought farmers an actual cash income of 183.7 million dollars. In 1939 cash farm income from potatoes was about 157.1 million dollars.

Potatoes are essentially a domestic crop. In recent years exports and imports have averaged around or under a million bushels each and have tended to cancel each other.

The consumption of potatoes is relatively inelastic. That is, under similar demand conditions, small crops usually result in larger returns to growers than do large crops.

To quite an extent the yield per acre is dependent upon weather conditions during the growing season, and the average has ranged during the past 10 years from 100 to 123 bushels per acre for the United States as a whole. When high yields occur the surplus of No. 1 potatoes is frequently sufficiently high to greatly depress the market price. About 10 percent of the crop is culls, and the loss from diseased and frozen potatoes and shrinkage in storage may also amount to as much as 10 percent of the total crop. Because of these conditions, which necessarily prevail in the potato-growing industry, there is a definite demand for a profitable means of utilizing the annual supply of cull and second-grade potatoes for other than direct food use, and also for diverting excess first-grade potatoes to non-food uses in years in which large surpluses occur.

At present, culls, which average as high as 37 million bushels a year, are used mainly as feed on the farms where produced. There is

a small potato starch industry in Maine, utilizing usually around 50,000 tons of potatoes per year. The production of white potato starch in this country in 1935 was about 33.8 million pounds, which was the highest on record. In 1937 the production was around 9.4 million pounds, which was slightly larger than the production in 1933. A large portion of the potato starch is used by the textile industry in the sizing and finishing of cotton textiles. It is also used in the manufacture of dextrine, soluble starch, malt sugar, beer, confectionery, and nitro-starch explosives.

New methods and equipment are being developed in the potato starch industry, looking toward increased output of a higher quality product. Utilization of potatoes for the manufacture of industrial and fuel alcohol, an extensive development in several European countries, has not proved, so far, to be economically feasible in the United States.

SWEETPOTATOES

Sweetpotatoes are the second largest vegetable crop in the United States and the largest in the South. During the 10-year period 1928-37 the average yearly commercial production was about 70.7 million bushels. In 1938 and 1939, the total commercial crop was about 76.6 million and 72.7 million bushels, respectively. Approximately 60 million bushels were grown in the Atlantic and Gulf States from North Carolina southward. Acreage harvested for the same period was: 1928-37, - 835,000 acres; 1938, - 883,000 acres; 1939, - 862,000 acres.

The farm value of the sweetpotato crop for the 10-year period 1929-38 has ranged from around 46.9 million dollars in 1932 to 76.1 million in 1929. Farm value for 1939 was estimated at 56.5 million dollars.

The food market for sweetpotatoes is somewhat inelastic, so that in years of high yields there are great surpluses of the marketable grade of this crop. Grading requirements for the food market are strict, and since the southern varieties tend to grow oversize, there is annually a large quantity of culls consisting mainly of oversize sweetpotatoes. In the South these amount to about 20 percent of the crop. Some of the culls are fed to cattle, but for the most part they are wasted. These conditions have led to an insistent demand for some form of industrial utilization.

Many varieties of sweetpotatoes contain more than 20 percent of starch. Root starches are indispensable for certain purposes, and except for small quantities of white-potato starch and sweetpotato starch they are not produced in the United States.

Experimental work was begun as early as 1895 with the object of establishing a sweetpotato-starch industry in the United States. Recently experimental work on this project has resulted in the establishment of a small commercial sweetpotato-starch plant operated by a local cooperative in Mississippi. In 1938 approximately 165,000 bushels of sweetpotatoes were processed for the production of about 1,640,000 pounds of starch, which was used largely in the textile industry. The sweetpotato-starch industry, however, has hardly passed the experimental stage.

Up to the time of the establishment of this cooperative starch factory, growers had been interested chiefly in obtaining as high a yield as possible of marketable sweetpotatoes, that is, potatoes of medium size and uniform shape. Since that time growers in the vicinty of the starch factory have been chiefly concerned with obtaining high yields of starch per acre. This has created a demand for research to find varieties of high starch content and has led to many other lines of research designed to develop high yields of starch per acre. Because of the need for further outlets for this crop, however, much of the present research is directed toward finding new food and industrial uses.

Byproducts of starch manufacture include: (1) the vines left in the field, which may have some forage or bedding value but give no promise for industrial utilization; (2) the residual pulp from which the starch has been extracted, which has potentialities when dried as a feeding stuff of high nutritive value; and (3) the wash waters from the starch tables, which must be denatured before discharge into rivers or sewage systems, unless they can be concentrated and dried for feed or for recovery of chemicals, as is done in corn starch plants.

SUGAR BEETS

The sugar beet is the most important domestic source of sugar in the United States, and this country ranks third in world production of beet sugar, Russia and Germany ranking first and second.

The center of the industry is in the Rocky Mountain and neighboring States. Michigan is the only State east of the Mississippi River that produces any quantity of sugar beets. About 73 percent of the sugar originating in continental United States is produced from the sugar beet. Annual production for the last 10 years has averaged well over a million tons. In many of the intensive farming districts of the Western States, where crops are grown under irrigation, the beet crop is the cash crop around which the whole agricultural system centers.

In 1938 a total of some 930,000 acres was harvested. The crop of around 11.6 million tons of beets, estimated to produce about 1.5 million tons of sugar, was processed in 87 factories, located near the farms on which the crop is grown. In 1939, 921,000 acres was harvested, production being about 10.7 million tons.

For the 1938 crop, the fabricated products -- beet pulp, molasses, and beet sugar-- had a value of nearly 100 million dollars. The value to the farmers of the sugar beets they produced was approximately 59 million dollars. In addition, the farm value of the beet tops (used for feed) is estimated at 4 million dollars. The sugar-beet seed produced was worth, on the farm, approximately 1.2 million dollars.

For the 1939 season, total pulp production is estimated at 158,000 tons of molasses pulp, 98,000 tons of dried pulp, and 1,919,000 tons of moist pulp.

Beet pulp obtained as a byproduct from beet-sugar factories offers an excellent opportunity for investigation with the objective of more profitable utilization. This material at present is used extensively as a feedstuff. Wet pulp at the sugar plant is valued at only $1 per ton, so that it serves as a very cheap source of raw material.

As a byproduct of the manufacturing process, waste lime accumulates around the factory, finding only occasional use as a soil amendment. The disposal of pulp water, Steffen's waste water, and lime sludge is annually presenting a more acute problem as stream-pollution laws become more rigid. Obviously, the elimination of these wastes through utilization is most desirable.

SUGARCANE

Louisiana is the main source of cane sugar in the continental United States. The production of sugarcane and the manufacture of sugar were the most important industries in the rich alluvial soils of the lower Mississippi Delta until they were almost wiped out in the early 1920's by the rapid spread of serious cane diseases. Since 1926, disease-resistant varieties released for commercial culture by the United States Department of Agriculture have brought about acre-yields of sugar which now reach or exceed former high levels. Some of the peat soils of southern Florida are being used very successfully for sugarcane production on a limited scale, but the development is hardly beyond the experimental stage as yet. The average annual production of sugarcane for sugar for the 10-year period 1928-37 was 3.6 million tons, with an average annual farm value of 11.7 million dollars. The average annual production of sugar (converted to 86° raw basis) was 253,400 tons. In 1938 and 1939 cane production for sugar was around 6.7 million and 5.8 million tons, respectively.

Sugarcane is grown for sirup production in most of the Southern States and is important as a cash and subsistence crop on between 200,000 and 300,000 farms. Average annual production of cane sirup for the 10-year period 1929-38 was 21.4 million gallons, with an average annual farm value for the same period of around 11.8 million dollars. In 1939 production was about 23.2 million gallons. These figures should be compared with those for sorgo sirup (page 53). In addition, the sugar mills produce around 3 million gallons of sirup a year.

Byproducts from the cane sugar industry are principally molasses, filterpress cake, and bagasse. From a fourth to a third of the molasses is used for table or cooking purposes. The balance, known as "blackstrap", is used principally in the fermentation industries, but large amounts are also used in mixed feeds. Total production of molasses from Florida and Louisiana cane have increased from 13.7 million gallons in 1928 to about 44.3 million gallons in 1938. For the year ending June 30, 1939, the molasses used at distilleries and industrial alcohol plants in the United States amounted to around 132 million gallons, most of which was imported. Alcohol produced from molasses amounted to around 135.8 million gallons. Total imports of molasses average around 230 million gallons a year, coming from the West Indies, Hawaii, and the Philippines. Imports of inedible molasses totaled about 177.3 million gallons in the calendar year 1938.

Sugarcane bagasse, as compared with the huge supplies of straw from the cereal grains that are available for industrial use, is of minor importance in continental United States. It is of much greater importance in our insular possessions, where sugarcane production is a major industry. Assuming that 1 ton of cane yields 500 pounds of bagasse containing 50 percent of fiber, there has been available in this county, for the 10-year period 1928-37, an average of 450,000 tons of bagasse fiber annually. On the same basis, 840,000 tons was potentially available from the 1938 crop.

The only industrial use developed for the product in this country, thus far, is in the manufacture of wall board and insulating board of various types. A weather-resistant mulch paper made from bagasse pulp and treated with asphalt has been used in Hawaii in mulching the sugarcane crop.

SORGO

Sorgo, like the other sugar crops, cane and beet, is not native to the New World. It was introduced about 100 years ago, and can be grown under a wide variety of conditions, from the Gulf States to Minnesota, and from coast to coast. The center of production is a wedge-shaped area with its base extending from eastern Colorado to southern Texas, and its apex resting in western Virginia.

Around 200,000 acres are devoted to the production of sorgo for sirup, and more than 10 times that amount to sorgo for forage. On many thousands of small farms sorgo is considered a valuable subsistence and small cash crop. Since 1929 the average annual production of sorgo sirup has been around 12 million gallons, with an average farm value of 6.68 million dollars a year. For the most part, sorgo sirup production is a farm industry, the grower operating his own mill or patronizing a local custom mill. (See discussion of sugarcane sirup, p. 51)

Byproducts from harvesting are the seed heads, leaves, and tops removed from the stalks. The seed crop averages 10 to 15 bushels per acre, and is claimed to have high feeding value, especially for poultry. Leaves and tops average from 5 to 15 percent of the weight of the crop. They may be dried or ensiled for feed, or plowed under for humus.

Milling byproducts include bagasse and skimmings. The bagasse, or crushed cane, may be used as bedding for farm animals, or composted for use as a soil improver. Skimmings from the sirup kettles or pans have recognized value in feeding farm animals, but they must be fed with care.

The combined value of the byproducts in the production of sorgo sirup is an important consideration in evaluating the crop, but the small size of individual plantings and the absence of centralized sirup production make it impracticable, under present conditions, to collect either the harvesting or milling wastes for industrial use.

TOBACCO

Tobacco has always been a major farm crop in the United States. For nearly 50 years, from a million to 2 million acres of land have been devoted to the growing of tobacco, and during that period its farm value has ranged from 50 million to 450 million dollars. The average crop for the 10-year period 1928-37 was 1,360 million pounds. The 1938 crop was about 16 million pounds greater. In 1939 production was about 1,769.6 million pounds, the largest crop ever produced in the United States and more than 121 million pounds larger than the previous record crop of 1930.

Tobacco is grown commercially in significant quantities in 20 States, and about 6 other States produce small quantities on a commercial basis. Four States, North Carolina, Tennessee, Kentucky, and Virginia, account for somewhat over 75 percent of the land devoted to this crop, and receive about the same proportion of the farm income. Very little tobacco is grown west of the Mississippi River.

There are many types and local varieties of tobacco grown, but these may all be grouped in 6 main classes,

1. Flue cured
2. Fire cured
3. Air cured
4. Cigar filler
5. Cigar binder
6. Cigar wrapper

Average production of manufactured products for the 10-year period 1928-37 has been:

Cigars (1,000's)		5,532,728
Cigarettes (1,000's)		129,241,035
Chewing tobacco)		
Smoking tobacco)	(1,000 pounds)	357,677
Snuff)		

Production of snuff, while of comparatively minor importance, has ranged from 35 to 40 million pounds annually for the past 20 years.

In addition to domestic manufacture, tobacco exports for the 1928-37 period have averaged 462.8 million pounds, or about one-third of the crop. War conditions in Europe are responsible for closing the market to shipments abroad, especially the British market for flue cured tobacco, and this, together with an above-average crop in 1939, has resulted in huge surpluses.

On the basis of 25 percent waste in stems and midribs, the average annual manufacturing waste has been 197 million pounds. In addition there are normal surpluses for which some use should be found.

The main outlet for tobacco waste and surplus has been in the manufacture of tobacco dust and nicotine extract for use in insecticides. It is estimated that 120 million pounds of factory waste and 12 to 15 million pounds of low grade leaf are used annually in this way.

In addition, as with most fibrous wastes, unknown quantities of tobacco stalks are used on the farm as fertilizer and soil improver.

There are recent developments in the use of nicotinic acid and denicotinized tobacco extract in the field of medicine.

In addition to established usages, experiments are under way for the development of high-nicotine, high-yield tobaccos in regions outside of present tobacco growing areas, the aim being to produce new nonsmoking tobaccos, specifically for industrial uses.

ALFALFA

During the last 20 years alfalfa has been growing rapidly in importance in the United States in comparison with other hay crops. It now ranks first with respect to production and farm value, having exceeded the combined production of clover and timothy every year, beginning with 1933.

The total acreage of alfalfa has increased from 8.6 million in 1919 to 13.5 million in 1939. The alfalfa hay crop for the last 10 years has ranged from 18.8 million tons in 1934, a year of short production due to drought, to 28.8 million tons in 1938, which is the largest crop on record. Production in 1939 was around 27 million tons.

Alfalfa is grown to some extent throughout most of the United States. It cannot be grown successfully on acid soils and is most easily cured in a climate that is not rainy during summer. Consequently the crop is grown most extensively in the West, under irrigation, and in the sub-humid parts of the Great Plains. It also does fairly well in the limestone regions of the East, where its culture has increased rapidly in recent years. The chief producing State is California, with about 3 million tons a year.

Alfalfa grown for seed is also an important crop. Average annual figures for the 10-year period 1929-38 are as follows: Harvested, 516,500 acres; production, 975,150 bushels; farm value, $9,518,700.

In 1939 alfalfa acreage harvested for seed was 817,000 acres, with a production of 1.4 million bushels of seed.

The straw resulting from threshing of the seed crop has about one-third to one-half the feeding value of the hay cut and cured while in the green and growing condition. It is practically all fed to cattle.

Alfalfa is used principally as a feed for dairy cows, but it is also an important foodstuff for other domestic animals, including horses, beef cattle, sheep, rabbits, and poultry. It is a good source of protein of high quality, as well as of carotene and calcium. These characteristics, combined with high yields, make it a valuable crop for hay and forage. The crop is also extremely valuable from the standpoint of crop diversification and soil enrichment. The practice of storing some forage crops as silage has been increasing in the dairy sections because it eliminates the loss in quality which often occurs when hay is field-cured. This is especially important for first-cutting alfalfa, and the practice may become of increasing importance during the next few years.

Alfalfa meal is the chief industrial product made directly from alfalfa. It is prepared by grinding or cutting alfalfa hay to rather coarse particles. It is used to a limited extent in the preparation of carotene for human and animal use, but its main outlet is in animal feeds. The bulk of alfalfa meal is made from field-cured hay delivered to the mills in bales, but in recent years increasing quantities have been made from alfalfa artificially dried in belt-conveyor or rotating-drum driers.

The advantages of grinding or cutting alfalfa hay into so-called meal are that there is less loss in feeding, the shipping charges are less for the ground product in bags than for baled hay, and the meal may be used for the preparation of mixed feeds. Some alfalfa mills are operated in connection with mixed-feed plants, but the greater part of the alfalfa meal produced is shipped to mixed-feed plants or is sold for feeding without mixing.

For the preparation of special-purpose feeds, alfalfa-leaf meal is a high-quality ingredient. The discarded stem meal then becomes a byproduct, used in low-grade feeding mixtures.

The commercial production of alfalfa meal has averaged 273,515 tons annually for the 10-year period 1928-37, with a price range from $15.50 per ton in 1932 to $28.00 in 1923 for No. 1 medium, bagged, in carlots. For the years 1937-38 and 1938-39, commercial production of alfalfa meal was 307,000 and 231,000 tons, respectively.

NAVAL STORES (TURPENTINE AND ROSIN)

The principal products now classed as naval stores, which originally meant pine tar and pitch, are gum spirits of turpentine, gum rosin, steam-distilled wood turpentine, wood rosin, destructively distilled wood turpentine, and sulfate wood turpentine. For these turpentines and rosins, standards have been set up under the Federal Naval Stores Act. The term "gum naval stores" refers specifically to gum rosin and gum spirits of turpentine, whereas the remaining turpentines and rosins are referred to collectively as "wood naval stores."

Gum naval stores, derived from the oleoresin of living southern yellow pines, are by far the more important group with regard to value, number of persons employed, area involved in production, and economic utilization of the land. Approximately 30 million acres of pineland out of the nearly 50 million acres in the Naval Stores Belt produce the annual crop of gum turpentine and rosin. The Naval Stores Belt includes North Carolina, South Carolina, Georgia, Florida, Mississippi, Alabama, Louisiana, and eastern Texas. About 350,000 people are dependent almost entirely upon the income from the production of the crude gum or its derived products, turpentine and rosin.

The annual production of gum naval stores varies widely, ranging from about 750,000 units in the 1908-09 season to about 340,000 units in 1918-19. The average is about 500,000 units. The production of gum naval stores for the 1937-38 season was about 535,000 units. A unit is one 50-gallon barrel of turpentine plus three and one-third 500-pound barrels of rosin. The average annual value of the crop to producers is approximately $25,000,000.

Normally 55 percent of this country's production of naval stores of all classes is exported. The percentage and quantities exported have decreased in recent years, owing primarily to the efforts of some important foreign consuming countries to be self-sufficient in these raw materials. A change in source of supply by those countries unable to produce naval stores has also tended to reduce exports from this country.

A recent timber survey by the United States Forest Service indicates that virgin and second-growth southern yellow pines are capable of yielding annually 800,000 units of gum naval stores on a sustained yield basis, and 300,000 units of wood naval stores, a production far in excess of any in the past.

The reported consumption of turpentine and rosin (combined gum and wood products) in the United States in the season 1938-39 is given by industries in table 9.

Table 9.--Consumption of turpentine and rosin (combined gum and wood products) by industries in the United States in the season 1938-39

Product	Turpentine (Bbls.-50 gal.)	Rosin (Bbls.- 500 lb. gross)
Abattoirs	0	2,173
Adhesives and plastics	526	11,816
Asphaltic products	1	968
Automobiles and wagons	354	328
Chemicals and pharmaceuticals	22,249	123,339
Ester gum and synthetic resins	9	108,611
Foundries and foundry supplies	576	7,950
Furniture	521	18
Insecticides and disinfectants	452	3,963
Linoleum and floor coverings	68	27,313
Matches	0	2,240
Oils and greases	37	23,767
Paint, varnish and lacquer	51,292	130,278
Paper and paper size	0	318,361
Printing ink	489	11,564
Railroads and ship yards	3,872	1,365
Rubber	125	3,919
Shoe polish and shoe materials	10,711	10,677
Soap	213	234,927
Other industries	1,800	4,415
Total industrial consumption reported	93,295	1,027,992
Not accounted for 1/	326,719	140,735
Apparent U. S. consumption	420,014	1,168,727

1/ Principally unreported distribution of turpentine through retailers who sell in small quantities to ultimate consumers, and of rosin for unreported industrial consumption; also for distribution through retailers who sell in small quantities to ultimate consumers.

VEGETABLE TANNING MATERIALS

Normally about 15 to 20 million dollars' worth of vegetable tanning materials are used each year in this country for making leather. These are derived from the bark, wood, leaves, fruits, and roots of trees or other plants.

The total value of the domestic production of tanning extracts and other tanning materials in the United States in 1937 was nearly 11 million dollars. These included about 364 million pounds of chestnut; 3.4 million pounds of sumac; 12.7 million pounds of oak; 778,000 pounds of gambier; 7.7 million pounds of hemlock; and 3.7 million pounds of wattle; or an aggregate weight of over 392 million pounds (196,000 tons), valued at almost 6 million dollars. In addition, other solid and liquid extracts, largely from imported raw materials, including quebracho and myrobalans, valued at nearly 2 million dollars, and other tanning materials valued at over 3 million dollars were produced. The above figures do not include domestic raw tanning materials leached and used directly by the tanner.

The annual consumption of tanning materials in this country, in terms of 25-percent tannin extract, is equivalent to about 450,000 tons. The tannins are used to make vegetable-tanned leathers, such as sole, belting, harness, case, bag, strap, and other heavy leathers, the average annual production of which in this country is estimated at about 425 million pounds.

Our most important domestic source of tannin is the wood of the American chestnut tree. Chestnut wood of the Appalachian region and quebracho wood of South America now furnish about two-thirds of our total supply of tannin for making leather. The chestnut, as is well known, is being steadily and rapidly exterminated by the chestnut blight.

Approximately one-half of the tannins used in this country for making leather come from foreign countries. Displacement of these foreign materials by domestic products offers a potential increase to home producers of approximately 10 million dollars annually. At present all domestic materials from which tannin is obtained are natural growths. If domestic production is to more nearly satisfy domestic needs, our native sources must be more completely and efficiently utilized or tannin producing crops must be found. Such crops would also serve, in part, to replace crops now in surplus.

DAIRY PRODUCTS

More than 100 billion pounds of milk, containing 13 billion pounds of solids in the form of fats, proteins, carbohydrates, and salts are produced annually in the United States. This output has a farm value of about 2 billion dollars or about 20 percent of the total farm income, and approaches the combined farm value of cotton, wheat, and tobacco.

There are three quite distinct "milksheds" in the country, in which the dairy problems are rather distinctive. One includes the Northeastern States in which the milk is mostly consumed directly in fluid form and manufacturing is a minor interest. The second is the Midwestern States, especially Wisconsin, Minnesota, and Iowa, in which the great bulk of the milk goes into manufactured products. The Pacific Coast States form a third region, differing not so much in interests as in respect to geographical isolation and climatic conditions.

In the northeastern fluid milk region the surplus problem is primarily one of season, and to some extent of weather; it varies also with economic conditions which affect the purchasing power of consumers.

About 40 percent of all the milk produced is consumed directly as such or as cream, and 4 percent is consumed as human food in the form of concentrated milk. Another 40 percent is separated to obtain cream for butter making. The skim milk obtained from all sources amounts to nearly 46 billion pounds annually. In addition to this enormous quantity of skim milk, the manufacture of creamery butter produces each year about 2.5 billion pounds of buttermilk, having practically the same composition as skim milk. Some 6.5 billion pounds of milk are required for the manufacture of the 650 million pounds of cheese produced annually; as a byproduct 5.8 billion pounds of whey containing 380 million pounds of lactose, protein, and salts is obtained.

In the 54 billion pounds of byproducts produced with the major dairy products there are 4.7 billion pounds of nonfat milk solids, that is, about 36 percent of all the milk solids produced in this country. These solids as produced are suitable for human food except that they lack palatability, are rather dilute, and are extremely perishable. The individual constituents include casein, lactose, numerous salts of probable value in nutrition, and all of the vitamins of the milk except the vitamin A.

The following flow sheet shows the various purposes for which milk is utilized, together with the amounts of the various products manufactured in a typical year.

In the United States dairying is primarily a domestic enterprise. Foreign trade in dairy products is relatively unimportant. During the last 30 years, with the exception of the World War period, imports of dairy products have exceeded exports, the principal item being various types of foreign cheese. In some years domestic prices of butter have been high enough to bring in some foreign butter over a tariff wall. During the 1920's imports of fresh milk and cream from Canada were relatively large. Our exports since the beginning of the World War have been mainly concentrated milks, but, in recent years (down to the beginning of the European war of 1939) this export trade had declined.

One of the major problems with respect to fluid milk is the utilization of the surplus resulting from seasonal or economic variations in supply and demand in the cities. Another large problem in this field centers about the reorganization of city milk distribution on the basis of recent advances in transportation, refrigeration, concentration, and sterilization.

The major problem of the creamery industry is to replace the butter of mediocre quality with butter of desirable flavor freshly made from sweet cream. The primary cause of poor flavor in butter is its manufacture from inferior quality cream.

Flavor is likewise the big problem in cheese manufacture. Cheddar or American cheese makes up 76 percent of the domestic production. A large proportion of it is inferior in flavor, is stored at low temperatures, and is sold with little real ripening. About 60 million pounds of cheese (roughly 10 percent of the domestic production) is imported each year; if this could be made in this country, it would provide a market for the milk of 135,000 cows. If the annual per capita consumption could be increased by one pound, a market would be created for all the surplus milk on the Atlantic seaboard. Greater consumption can be obtained by producing a more uniform grade of distinctively flavored Cheddar, and by developing new cheeses on the order of some of those now imported.

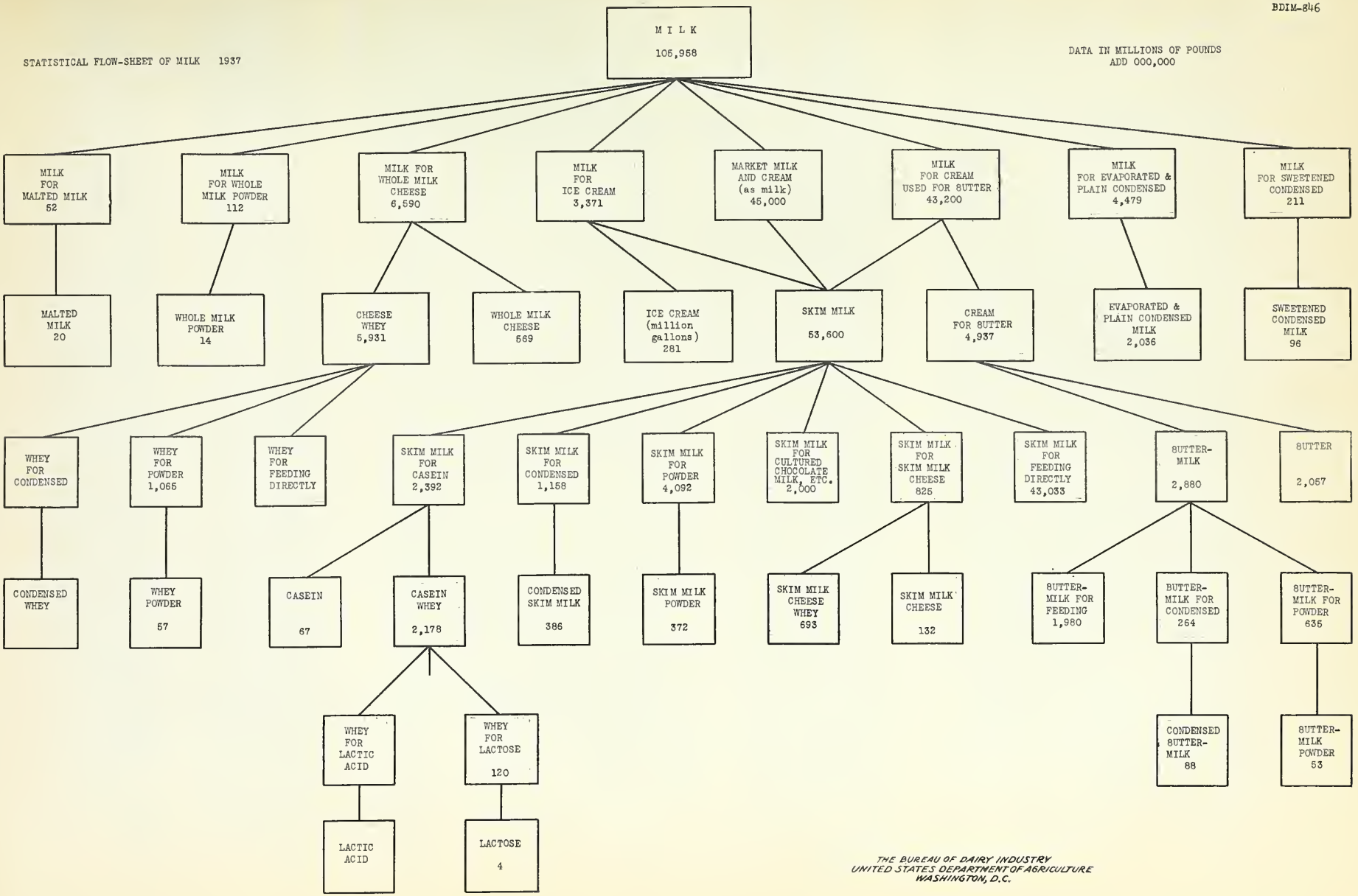
Production of ice cream in commercial factories is now approximately 300 million gallons annually. This great volume has been attained within a few years and has been accompanied by very rapid changes in the technique of manufacture as well as in the business of obtaining and storing the perishable raw materials and distributing the finished product.

Ice cream makers have been much concerned over the question of maintaining a supply of cream, or its equivalent, and of nonfat milk solids to take care of the great variations in the demand for ice cream. There is not only a wide seasonal variation but a rise and fall from day to day as weather conditions change.

In respect to the byproducts skim milk and whey, the chief economic loss is through inefficient use rather than by actual wastage. The great bulk of the skim milk is fed on farms and is only potentially

STATISTICAL FLOW-SHEET OF MILK 1937

DATA IN MILLIONS OF POUNDS
ADD 000,000



THE BUREAU OF DAIRY INDUSTRY
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C.

available for manufacturing purposes. Of the skim milk in creameries or milk plants, over 700 million pounds is used in the making of cottage, pot, and bakers' cheese, 4 billion pounds in dried skim milk, and 1.7 billion pounds in cultured buttermilk and other beverages. Nearly all the buttermilk is fed to farm animals either in its natural condition or in a semisolid or dried form. The 48.5 million pounds of casein produced in this country in 1938 required for its manufacture about 1.7 billion pounds of skim milk. Considerable quantities of whey are actually wasted, but this situation is rapidly changing. The greater part is now fed to animals, about 1 billion pounds being dried annually for use as a constituent of proprietary feeds. About 120 million pounds of whey are used annually in the manufacture of lactose, and about 5 million pounds are fermented annually to make lactic acid.

Comparatively little of these byproducts is available at any one place, but there are many centers of production where supplies of either skim milk or whey could be concentrated without too great an expense. The wide seasonal variation places definite limits on the type of manufacturing processes that can be operated profitable. Any new method of utilizing byproducts must be able to compete with present use and place a sufficiently high price on skim milk to induce farmers to bring whole milk to the creameries for separation.

Milk is the only natural source of lactose, which is a sugar composed of one molecule of glucose and one moecule of galactose. Lactose constitutes more than one-third of the solids in normal milk and is the major constituent of sweet whey. On account of its relative insolubility and lack of sweetness, it has found little place in foods except in those prepared for infants or for special dietetic uses. It is attracting industrial interest, however, because of the huge potential resources available. Several methods of separating the lactose from whey and even from skim milk are available. The most obvious new use of lactose is fermentation to lactic acid, which can be done economically. This process is now in operation in one plant. The presence of two functional groups in lactic acid, one alcoholic, the other acidic, is the basis of much of the research on new derivatives of this compound.

Casein is an important byproduct of milk. Along with wool, silk, and gelatin it is one of the important animal proteins that are now being used industrially. This group of proteins has been the subject of widespread investigation, but the question as to what form of protein available in farm commodities is most feasible for industrial use is not yet settled.

The largest outlet for casein in this country is in paper coating. Other uses are in plastics, glue, paint (mostly cold water paint), and insecticidal sprays. One of the newest and most promising outlets is in the manufacture of a casein base textile fiber, several processes for which have been developed on an experimental basis.

POULTRY AND EGGS

The poultry industry of the United States is widely distributed on American farms; in value of output it ranks next to the meat and dairy industries. Its products are used almost exclusively as human food. To a limited extent byproducts may be used in feeds, but at present many of the byproducts are still merely wastes or even constitute a nuisance.

For many years the farm poultry enterprise centered in and around the Corn Belt, in the region of cheap feed. In recent years, however, there has been a marked tendency for poultry production to centralize in commercial areas, notable around the Northeastern coast cities, the large industrial centers of the Midwest and the San Francisco and Los Angeles areas of California, and in the Puget Sound area of Washington.

The high point in number of chickens on farms, about 475 million, was reached at the end of 1927. The number had declined to about 387 million at the end of 1937, owing mainly to droughts, feed shortage, and low prices; but the number had increased to 413 million at the end of 1938, with a farm value of nearly 290 million dollars.

Of the total number of chickens raised in 1935, some 238.2 million were used on farms and 382.9 million sold. In 1938 about 240.1 million chickens were consumed on the farm and about 380.5 million were sold. Similarly, of about 2,775 million dozen eggs produced in 1935, some 677.5 million dozen, or 24.4 percent, were used on farms (58 million dozen for hatching and 619.5 million dozen otherwise used in the home), and 2,097.5 million dozen were sold. The farm disposition of eggs in 1938 was as follows: 50.3 million dozen for farm hatching; 702.7 million dozen consumed in the farm household; and 2,331 million dozen sold. The farm value of eggs in 1938 was about 617.7 million dollars, based on the average farm price for the year of 20.3 cents a dozen.

The direction of movement to market of poultry products is toward the four great centers, Boston, New York, Philadelphia, and Chicago, with San Francisco also figuring as a fairly large receiving center.

Surplus stocks of eggs are accumulated in cold storage during the months of heavy production, including March, April, May, and June. They are usually at their peak about August 1. Storage stocks are moved into consumption during the fall and winter when the production is low.

In addition to eggs, a substantial amount of dressed poultry is held in cold storage. These stocks increase during the heavy marketing season in the fall and early winter, usually reaching their seasonal peak sometime in January. The outward movement of stocks then takes place until these reach a low level sometime in August.

According to figures of the Bureau of the Census, (see table 10) the number of chickens dressed and packed has been fairly constant since

1929, averaging about 325 million pounds, while turkeys dressed and packed have more than doubled -- from 31 million pounds in 1929 to 73 million pounds in 1937. Ducks, geese, and other poultry have not changed greatly in quantity packed.

In addition to the cold-storage supply of shell eggs, approximately 208 million pounds (178 million dozen) are broken out and frozen either as whole eggs or separately as yolks and whites. It is also possible to obtain dried whole egg, dried egg yolk, and dried egg albumen. At the present time most of the dried egg products are imported. Quick-frozen poultry, a comparatively new item, already has reached a total production of more than 2 million pounds.

Poultry byproducts are of two types -- the slaughterhouse waste from cold-storage, canned, and quick-frozen fowl, and the incubator waste from commercial hatcheries. In full-drawn poultry, there is an estimated 25 percent waste. In quick-frozen birds alone this represents more than 1,600 tons of offal, largely concentrated at packing plants. Feathers constitute an important and troublesome item, with an exceedingly variable market.

The waste from 12,000 or more hatcheries, which have a total capacity of 325 million eggs at one time, amounts to at least 25 percent of all eggs set, or a total of 10 million dozen infertile eggs and dead embryos. This represents a waste of at least 15 million pounds annually in the hatchery industry. In addition, at the hatcheries specializing in day-old chicks for laying flocks, thousands of baby cockerels are killed and thrown away.

Table 10.--Amounts and values of poultry products in the United States, specified years[1]

Product	1937	1935	1931	1929
Poultry, dressed and packed:				
Total pounds	451,659,229	----	----	----
Total value	$97,332,316	$90,333,714	$93,131,759	$122,466,372
Chickens: [2]				
Pounds	330,190,937	306,316,832	342,037,719	329,689,483
Value	$70,587,333	$61,945,248	$75,572,064	$94,324,735
Turkeys: [2]				
Pounds	73,575,237	45,236,127	35,638,496	31,427,113
Value	$16,472,207	$11,124,925	$8,983,626	$9,908,921
Ducks: [2]				
Pounds	5,960,653	7,063,084	5,633,236	5,659,706
Value	$1,152,105	$1,369,760	$1,097,787	$1,385,853
Geese:				
Pounds	3,704,862	4,962,377	4,170,092	)
Value	$762,488	$903,517	$783,343	)
Other poultry: [2]				) 2,781,999
Pounds	1,404,859	1,335,007	1,235,816	) $654,984
Value	$340,924	$282,993	$291,952	)
Poultry not reported by kind:				
Pounds	36,822,701	----	----	----
Value	$8,017,259	$14,707,271	$6,402,987	$16,191,829
Poultry, canned, value	$2,334,639	$1,968,926	[3]/$2,763,845	)
Chicken, potted and devlied:				)[3]/$3,748,475
value	$59,200	$30,600	[3]/ $38,876	)
Chicken broth and soup, and other soups, value	$2,239,160	$2,187,593	)	)[3]/$1,360,567
Chicken and noodles, chicken a la king, etc., value	$379,166	$548,238	) $1,871,292)	) $222,766
Feathers sold:				
Chicken:				
Pounds	1,897,403	)		
Value	$85,803	)		
Other:		) $107,097	$121,466	$408,324
Pounds	706,000	)		
Value	$95,998	)		

[1]/From Biennial Census of Manufactures, 1937.

[2]/These figures are incomplete to the extent to which data for the specified kinds of poultry are included in the figures for "Poultry not reported by kind."

[3]/Revised figures.

MEAT AND MEAT PRODUCTS

The main area of meat production in this country corresponds to the region of surplus feed. This includes the central grain belts, roughly within the vast Ohio, South Dakota, Texas triangle. The total yearly income to producers averages something over a billion dollars from hogs, a little under a billion from cattle, and some 150 to 200 million dollars from sheep. The general direction of market movement of meat products is from western ranges to midwestern feed lots and thence to large eastern cities.

Over the last 40 years the annual production of beef has ranged from 5 to 7 billion pounds; veal production has climbed from less than half a billion to a billion pounds in recent years. Pork production has been about 6 to 9 billion pounds plus an additional 1.5 to 2.5 billion pounds of lard. Production of mutton, and more especially of lamb, likewise has steadily increased from less than 500 million pounds to about 900 million pounds in the last few years.

Formerly the United States was a large exporter of meat products, especially pork. After the World War, however, our export market dwindled.

Stocks of meat animals are carried on the farms at all times. In cold storage, there is usually from 500 to 800 million pounds of pork at the high point about March 1. In addition, the cold-storage stocks of lard have been from 100 to 200 million pounds in recent years. Ordinarily considerably less beef than pork is carried in storage. The movement of pork into storage is usally from early November to March; that of lard is usually from December to August. Most of the outward movement of these products occurs in the summer and fall. The total movement into storage is influenced considerably by the prospective supply of hogs for summer slaughter in relation to winter marketing.

The principal products of these animals, other than the actual dressed meat, are lard, cattle hides, calfskins, wool and mohair, and sheep and lamb skins, as well as manufactured products such as canned and cured meats, oleo oil, and stearin. Some of these are often classed as byproducts, although they have substantial sales values.

Of the dressed meat byproducts used as food, the more important articles are tongue, brains, meat portions of the head, livers, kidneys, tails, sweetbreads, pigs' feet and tripe, and intestines used for sausage casings. Intestines are also used for inedible products such as surgical ligatures and violin strings.

The principal inedible byproducts (except wool, hides, and skins) include the following:

(1) Glands, such as the thyroid, parathyroid, pituitary, pineal, thymus, adrenal, gonads, and pancreas, from which are derived a variety of pharmaceuticals, including insulin, pepsin, pancreatin, thyroid extract, adrenalin, and many others. Due to the necessity of obtaining the glands quickly and in commercial quantities in order that their medicinal properties may not deteriorate, only the larger meat packers are able

to serve the market for this class of product. Improvements in methods of preservation might make it possible for smaller packers to enter the field more extensively.

(2) Bones, hoofs, and horns, which are used principally for making fertilizers, feeds, glue, gelatin, bone byproducts such as combs and knife handles, bone black, oils, and soap greases.

(3) Hair, which is used principally for padding, upholstering, and brushes.

(4) Sinews, fats, and blood, which are used in the preparation of a variety of products such as blood albumen, glue, gelatin, fertilizers, animal feeds, soap, glycerin, and a variety of oils and tallow.

Meat packers quite generally realize that it is usually more profitable for them to utilize as much of their product as possible for edible purposes. Only those byproducts, therefore, which, because of their nature or because of health or sanitary restrictions, cannot go into edible channels are otherwise utilized under usual market conditions.

WOOL AND MOHAIR

Wool is not one of the products produced in surplus on American farms. For many years the textile mills of this country have used more wool than we produce and have had to import 30 to 40 percent of their requirements.

It is estimated that there are in the United States about 472,000 wool producers and over 52 million sheep and lambs. In the 10-year period 1929-38 the average annual production of shorn wool has been about 360 million pounds. In addition, there is an annual production of 54 million to 67 million pounds of pulled wool, which is obtained from the skins of slaughtered sheep.

The wool-growing industry has shifted westward until now two-thirds of the shorn wool is produced in the Rocky Mountain and Pacific States. Texas is the largest producer. Generally speaking the Rocky Mountain States produce the fine wools characteristic of the Rambouillet and Merino breeds, whereas farther east the Down breed predominates and the wools are coarser.

Wool, like other animal fibers, is a protein substance, whereas vegetable fibers are composed largely of cellulose. On account of their protein content animal fibers take certain types of dyes which cannot be used on vegetable fibers, they are less water-absorbent, more resistant to deterioration by dilute acids, and have some degree of fire resistance. Animal fibers also have physical properties which render them superior to vegetable fibers for the manufacture of certain kinds of textile fabrics.

Mohair production has ranged from 10 million to nearly 20 million pounds annually during the last 15 years. Texas produces more than 80 percent of the clip. It is used especially for the manufacture of plush fabrics for automobiles and furniture.

Wool and mohair are the only animal fibers produced commercially in the United States for spinning.

Wool grease obtained in the scouring of wool has been found useful for many industrial purposes including leather dressing, water-proofing compositions for fabrics, lubricant in wire drawing, treating of cordage, and as an ingredient in paints. Lanolin, obtained from wool grease, is used medicinally as a base for ointments.

HIDES AND SKINS

Hides and skins are among the highest-price-per-pound raw materials that agriculture produces. The tanner often pays as much or more per pound for the best flayed and cured hides and skins of cattle and calves than the butcher pays for the dressed carcasses of these animals. Yet, because they are byproducts of another industry and frequently are marketed by undiscriminating methods, hides and skins are all too often treated with but little regard for what should be done to realize their maximum value.

It is generally considered that for cattle an average of about 7 percent of the live weight and about 11 percent of the value of the live animal is in the hide. In the case of calves, the skin may equal as much as 20 percent of the value on the hoof.

The importance of hides and skins is shown by the fact that about 125 million are tanned annually, worth around 200 million dollars. The leather produced has a normal factory valuation of around 450 million dollars. It is converted into shoes, belting, harness, and other goods for which consumers spend yearly close to 2 billion dollars. Domestic production is about 40 million hides and skins annually, worth well over 100 million dollars. It is necessary to draw upon foreign countries for the balance.

There is a possibility of substantially enlarging the income to agriculture by improving the quality of hides and skins. In this country animals are raised not primarily for their hides and skins, but for other purposes such as meat, milk, and wool. Improvement in the inherent properties of domestic hides and skins, as through breeding and special feeding, would place these materials in a stronger competitive position. Estimates of the annual monetary loss due to spoilage and waste of hides and skins from faulty skinning, poor cure, and improper handling have ranged from 10 to 20 million dollars. This loss is additional to that occurring from insects or parasites infesting the living animal and from diseases.

For the benefit of agriculture and the leather industry, therefore, it is evident that considerably more attention needs to be devoted to the production of high quality hides and skins and to better methods of marketing.