THE ECONOMICS OF STARCH PRODUCTION IN KANSAS

by

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INTRODUCTION

Since the development of power farming and the loss of the foreign market for agricultural products, the increased use of farm products in industry has attracted much attention in the United States. It is hoped by practically every one interested in improving the income of the American farmer that new industrial uses can be developed for many of the farm products which formerly were marketed abroad, thus developing a domestic demand for farm products to replace the decline in foreign demand.

As a result of the attempt to find new uses for farm products, a great deal of research has been done by chemists, chemical engineers, and others in attempting to develop processes for extracting and synthesizing new products from varied farm products. Some of the developments as a result of this research have proved to be economical; for instance, the development of rayon and cellophane in which cotton is an important ingredient, the use of soybeans in paints, plastics, and many other products.

Large numbers of the products which have been developed cannot be economically produced at the present time and perhaps can never be. Nevertheless, the successful development of one new industry producing important products from farm crops would more than offset the cost of several unsuccessful experiments.

However, a new industry should not be developed nor should an old industry be carried into new areas until a careful analysis has been made to determine whether or not it would be assured of a fair degree of success.

Purpose and Scope of the Study

The purpose of this study was to determine whether or not it would be economically advisable to establish Irish potato, sweet potato, corn, or grain sorghum starch factories in Kansas, in view of using Kansas farm products as sources of raw materials. The main part of the study was devoted to an analysis of the economics of Irish and sweet potato starch manufacture.

In dealing with the problem, farm commodities were considered separately in an attempt to analyze each commodity as a source of raw material for a starch factory.

The first phase of the study of each commodity was to show the potential supply of raw materials over a period of years. This included average acreages, yield per acre, and production figures for the state and by counties to indicate the importance of the industry and the important producing areas in the state. The prices received by farmers and transportation costs also were analyzed to indicate the prices a starch factory would have to meet to obtain raw materials.

The second part of the analysis of each commodity was devoted to determining as nearly as possible the facility and

operating costs and labor requirements of a starch factory of desirable size. An attempt also was made to show the probable yields of the finished product from a given unit of raw materials and the value and possible use of any by-products produced.

Third, the prevailing prices paid for starch on the terminal markets were studied to establish a basis for estimating the potential demand and the probable prices that could be obtained for starch produced in Kansas.

Fourth, the data were summarized and conclusions and recommendations were made for each commodity in view of the economic feasibility of developing a starch factory in Kansas.

Sources of Data

Acreage, yield and production data were taken from "Agricultural Statistics" (2,3). Prices received by farmers for the commodities studied were compiled from "Crops and Markets" (14). Prices of Irish and sweet potatoes on the terminal markets of Chicago and Kansas City were compiled from "Miscellaneous Fruit and Vegetable Reports" (27,28).

County yield, acreage, and production data were obtained from the "Biennial Reports of the State Board of Agriculture of Kansas" (7).

Questionnaires were mailed to 100 potato producers in the Kaw Valley to determine their attitudes concerning the development of a potato starch factory in Kansas as well as the

quantities of potatoes they would be willing to furnish to the factory at prices the factory could afford to pay.

Transportation rates were obtained from the Topeka Chamber of Commerce and from data obtained by interviewing local truckers at Topeka, Kansas.

Exports, imports, and domestic production of the various kinds of starches were obtained from information furnished through correspondence with the United States Department of Commerce.

Starch prices on the New York market were compiled from the quotations in the "Oil, Paint and Drug Reporter" (33). Wholesale prices for starch in Topeka were compiled from the quotations in the "Topeka Merchants Journal" (54).

Practically all of the information concerning the economic requirements of sweet potato starch factories were obtained from correspondence with, and literature furnished by, H. S. Paine, Chief, Carbohydrate Research Division, Bureau of Agricultural Chemistry and Engineering, United States Department of Agriculture.

The economic requirements for Irish potato starch factories were obtained through correspondence with, and literature obtained from, J. W. Gannaway, Jr., Associate Marketing Specialist, Marketing Section, Agricultural Adjustment Administration, United States Department of Agriculture, and C. A. Brautlecht, Professor of Chemistry and Chemical Engineering, University of Maine,

Orono, Maine. Some information was obtained by correspondence with managers of potato starch factories operating in Maine.

Questionnaires were sent to a number of men actively associated with starch production and to the state colleges of every state mentioned in the literature as having had a starch factory. While the correspondence carried on was interesting and somewhat pertinent data were obtained, the information, for the most part, was general.

Review of Literature

The fact that the manufacture of starch is an old industry was shown by Eynon (18). He stated that, as early as 184 B. C., Marcus Porcus Cato described a method of making starch from cereal grains and that, according to Pliny the Elder, the inhabitants of the Isle of Chios were the discoverers of the method of obtaining starch from grain. Wheat, apparently, was about the only raw material used in the manufacture of starch from primitive times until the latter part of the eighteenth century.

The manufacture of wheat starch was an important industry in Holland during the Middle Ages; this starch was considered to be of very good quality. The principal use of starch at that time was in the laundry for the stiffening of fabrics; it was regarded as an expensive luxury suitable only for use by the aristocrats and important dignitaries. Apparently the custom of powdering the hair was started in France in the sixteenth

century. A large amount of starch was used for this purpose.

It also is interesting to note that Leonardo da Vinci, one of the forerunners of aviation, recommended starch to stiffen the fabric in airplane wings.

Starch was introduced into England during the reign of Queen Elizabeth. She is said to have appointed a special court official for laundry starching. Mlle. Van der Plane, a Flemish woman, came to London in 1564 and gave lessons in starching. Starch probably was manufactured on an industrial scale in England at that time or soon afterward. During the seventeenth century starch was so much in demand that a food shortage was caused, making it necessary to restrict, and in some cases prohibit, the manufacture of wheat starch.

In the eighteenth century attempts were made to find sources of starch cheaper than wheat. In 1732 Siever de Guife recommended to the French government that potatoes be used as a source of starch. The potato starch industry in Germany was started about 1765 by the encouragement of Fredrick the Great. Dubomel du Monceau, writing in 1772, said that when prices of cereals were high, arrowroot, potato, and arum starch were used. He described the methods of manufacturing starch at that time and mentioned its use in many industries.

In the nineteenth century there was a large expansion of the starch industry, largely because of the demands of the textiles, color printing and paper industries, and because of the discovery

that starch is readily converted into glucose and dextrins. Since the beginning of the nineteenth century potatoes have been the principal source of starch in Germany and corn has been the principal raw material in the United States.

Corbett et al (12) in their history of the starch industry of the United States stated that potato starch manufacture was first mentioned in 1831 by a brief article in a farm journal. According to this article, 45,000 bushels of potatoes were utilized for starch production in a small New Hampshire town. At this time New England potato growers had no outlet for their potatoes except for a limited consumption in their home towns. Even the price of 10 to 15 cents a bushel was enough to encourage growers to increase their acreages of potatoes. A small factory was erected in Columbia, New Hampshire, in 1842 and another in Colebrook, New Hampshire, in 1846. By 1869 the competition among the starch factories in this area was general and in some years the growers received as much as 50 cents a bushel for their crop while, at the same time, starch was selling as high as $180 a ton--nine cents a pound. The growers found that the intensive cultivation of potatoes was depleting their soil, so they curtailed production. As a result, the output of starch was decreased to about one-third the former quantity.

The first starch factory in Maine was developed in 1871 at Caribou. The industry expanded rapidly and at the height of the business there were 40 factories in operation in the county.

The average price for potatoes was 20 cents a bushel. The demand for Aroostook potatoes for table stock soon caused the starch industry to dwindle until at the present time the factory supply of potatoes is made up almost entirely of surplus and culls. The continuation of the potato starch industry in Aroostook County, Maine, is largely--if not wholly--a result of the extent of the crop produced in any season which provides a good supply of cull potatoes.

Corbett also gave an itemized account of the manufacturing costs in Aroostook County based on the 10-year average, 1902 to 1911, inclusive. The average cost was estimated to be 3.51 cents a pound and the average selling price was estimated to be 3.8 cents a pound, leaving a profit to the starch manufacturer of 0.29 cents a pound or 29 cents a hundred pounds of starch. Corbett also stated that, although the equipment for the operation of a starch factory is relatively inexpensive, the yearly depreciation is great, thus adding to the overhead costs per unit of output, especially if the operating period is short. Corbett mentioned the following factors which limit a more intensive development of the potato starch industry in this country:

1. The supply of cheap potatoes is undependable.
2. The margin of profit is narrow because of the cheapness of foreign-made starch.
3. The operating season usually is too short to warrant

the large investment of capital necessary to operate a factory.

Wiley (59) stated that small, unripe, scabby, rotten potatoes unsuitable for edible purposes yield only about six to seven pounds of starch per bushel of potatoes and that the starch resulting from these poor-grade potatoes is neither uniform nor pure. When potatoes are $1 a barrel, starch factories usually pay from 30 to 60 cents a barrel for cull stock.

Mr. Wiley stated further that in 1900 there were 45 factories in Aroostook County, Maine. The average factory cost about $13,000 and produced about 1,200 pounds of starch daily.

In another article, Wiley (58) stated that manufacturers in Germany have an advantage over those in the United States in producing potato starch in that German producers have developed potatoes of higher starch content than are to be found in this country. He gave the following data as an indication of the content of potatoes in the United States as compared to Germany:

German potatoes (by Konig)	20.69 per cent starch
German potatoes (by Linter)	19.7 per cent starch
German potatoes (by Wolff)	20.7 per cent starch
Good Vermont potatoes	14.51 per cent starch
Good Maine potatoes	18.29 per cent starch
Good New York potatoes	19.28 per cent starch

To obtain a higher starch yielding variety in this country, Wiley stated that it is necessary to improve a native strain, as foreign varieties tend to lose their superior qualities after

being grown a generation in the United States.

According to Horner (20) the United States Department of Agriculture estimated that 10 per cent of the Michigan crop and 11.9 per cent of the United States crop, as a whole, are unfit for use on the table or for seed. This is some indication as to the per cent of poor-grade potatoes available for starch production.

Paine (35) gave the following account of work done in the sweet potato plant at Laurel, Mississippi. He stated that the potato starch produced from the Irish potato in Aroostook County, Maine, has been practically the only source of domestic root starch and as long as the industry remains solely on the basis of cull (sometimes No. 2) potatoes, it will be limited. Whether or not a domestic white potato starch industry could be developed in this country on the basis of potatoes grown specifically for starch, as in Europe, has not been demonstrated.

He further stated that the first experimental work on sweet potato starch in the United States was done by the South Carolina Agricultural Experiment Station in 1895 and was continued for several years. The La Fource Starch and Refining Company, Thebodaux, Louisiana, produced sweet potato starch by a simple sedimentation process in 1928. German starch machinery was used, but no chemical treatment was employed. The starch produced was unsatisfactory; consequently, the operation of the plant was discontinued. In 1933 more than 30 per cent of

Japanese starch production was from sweet potatoes. The industry in Japan is about one hundred years old and is on a crude household or small-factory basis. As a result, the starch is not uniform and is off-color.

As white color is very important, it was evident that if a sweet potato starch industry were to be established in the United States, the development of mechanical equipment for efficient, large-scale operation and chemical treatment for elimination of color would be essential. Balch and Paine (5) originated a process in which sulphur dioxide was used in the screening systems, followed by extraction of the pigment with alkali. Thurber (51) later proposed the use of an alkaline sodium sulphite solution in the milling and screening systems and in starch purification to obtain a white starch.

The starch content of the sweet potatoes processed in the Laurel, Mississippi, plant has varied from year to year as affected by climatic and other factors. However, the operating data show a total extraction of recoverable starch equivalent to about 85.8 per cent of the starch in the potatoes--10.8 pounds anhydrous starch or 12.3 pounds commercial starch (12 per cent moisture content) per 60-pound bushel--if all starch in the waste water were recovered and the unaccountable loss disregarded.

Dried pulp, the by-product from sweet potato starch manufacture, contains about 42.6 per cent starch and 11.4 per cent

water; the average yield is about 6.4 per cent of the weight of potatoes. Dairymen have been willing to pay $27 a ton for this dried pulp for feeding purposes. The results of tests conducted by the Mississippi Experiment Station show that sweet potato pulp is more like corn in composition than any other of our common grains. It is about 95 per cent as valuable as a feed as crushed ear corn and is equally palatable.

Paine further stated that in the past the southern sweet potato crop has been on a small-plot basis and that poor yields and poor methods of production have been followed. As a result of considerable research, Mississippi growers are now planting varieties yielding a higher percentage of starch and are using more efficient machines and methods.

According to Paine, a capacity of fifteen tons of starch a day is regarded as the minimum for a factory using the present manufacturing procedure. The Laurel plant has a capacity of about ten tons of starch a day, and its processing costs exclusive of raw material are about one cent per pound of starch produced. If a factory could be developed on a considerably larger scale, the fixed costs and labor cost per unit of starch produced might be reduced until the manufacturing cost (exclusive of raw material) would amount to only 0.75 cents a pound of starch and possibly less.

Scrivanich (41) advocated the development of sweet potato starch factories, stating that the United States has a potential

annual output of 100,000 tons of sweet potato starch, which, if developed, would replace at least part of the 240,000 tons of foreign root starches now imported each year. In addition, this new industry offers a possible new market for 40,000 to 50,000 tons of fertilizers.

In most fields, Scrivanich (41) stated, cereal and root starches are used for entirely different purposes. Thus sweet potato starch, which is a root starch, will not compete with domestically-produced cereal starches but will replace imported foreign starches such as arrowroot, sago, and tapioca.

He also explained the unique quality of sweet potato starch in various industrial uses. In the textile industry, sweet potato starch is superior to many other kinds of starch. Probably because of the minute-sized particles, sweet potato starch penetrates fabrics well and does a true "sizing" job, while many other starches fail to penetrate as well and tend to flake off at the slightest provocation.

Scrivanich gave the following examples as proof of the superior qualities of sweet potato starch: (1) A Southern textile mill used 85 pounds of sweet potato starch instead of 110 pounds of the starch previously used; the looms using yarn sized with sweet potato starch made 244 less stops caused by knots and broken threads. (2) A Philadelphia laundry used 20 per cent less sweet potato starch than the type of starch formerly used and increased its output because of ease of operation and more

satisfactory results. (3) One large confectionery increased texture, appearance, and the keeping quality of its product by the addition of sweet potato starch.

As it was felt that none of the references available contributed to the economics of corn or sorghum starch production, the review of literature has been confined to Irish and sweet potatoes.

THE STARCH SITUATION IN THE UNITED STATES

The starch industry in the United States is more important than the average citizen realizes. Records indicate that, on the average, about 1,114,000,000 pounds of starch are used annually for various purposes in this country (Table 1). Of this quantity, approximately 257,000,000 pounds are imported and the remainder is manufactured domestically. About 914,000,000 pounds of starch is produced in the United States annually, of which approximately 57,000,000 pounds is exported.

Table 1. Total average annual consumption, imports, exports, and production of starch in the United States, 1931-37 (48).

Production/1	913,668,932 pounds
Imports	257,151,000 pounds
	1,170,819,932 pounds
Exports	56,883,000 pounds
Consumption	1,113,936,932 pounds

/1 United States Department of Commerce.

Most of the starch produced in the United States is cereal starch, which averages about 800,000,000 pounds annually (Table 2). Most of the domestic starch is made from corn, but some is produced from wheat, rice, and other products. Corn starch is the principal starch exported, an average of slightly more than 56,000,000 pounds being exported annually during the 1931-37 period. If more corn starch factories are developed, most of the resulting increase in the United States production of corn starch probably will have to be marketed abroad. Otherwise, domestic outlets will have to be developed to take care of the increased production. At the present time, corn starch is used in many different industries and in a variety of products (Fig. 1).

Pearl corn starch on the New York market sold for an average of about $2.95 a hundredweight in 1938 and 1939 (Fig. 2). Powdered corn starch in the same years sold for about $3.05 a hundredweight and usually averaged a few cents more per pound than pearl starch. Prices of both types of starch are subject to a slight seasonal variation (Figs. 3 and 4).

Practically all of the imported starch is root starch, most of which is manufactured from cassava (tapioca), a tropical plant (Table 3). Most of the 257,000,000 pounds of starch imported is to supply the demand for root starch which is not fulfilled by cereal starch. This offers an opportunity for domestic potato and sweet potato starch manufacturers to market a

Table 2. United States production of starch, 1904-1937/2.

Year	Corn Starch		Potato Starch		Other Starch/3	
	Pounds	Value	Pounds	Value	Pounds	Value
1904	311,140,814	$ 8,878,450	27,709,400	$ 924,476	17,845,121	$1,124,612
1909	638,825,366	15,962,916	24,873,415	823,019	13,836,866	728,888
1914	574,247,697	13,784,654	23,540,472	718,006	22,976,178	1,281,121
1919	727,962,234	40,557,660	16,477,186	1,099,028	39,073,667	2,746,185
1921	860,224,469	24,305,565	8,924,927	323,192	28,415,798	991,782
1923	839,382,402	28,727,841	4,689,751	182,168	19,300,076	990,049
1925	854,125,467	33,716,307	10,127,556	409,214	13,943,521	951,026
1927	1,012,175,194	32,316,879	8,014,425	434,361	17,565,605	1,146,065
1929	1,046,435,117	39,284,604	14,539,709	491,555	62,476,079	3,053,896
1931	733,326,057	22,954,105	15,599,328	408,444	46,038,596	2,240,763
1933	960,251,935	27,131,689	9,283,400	247,685	50,807,218	2,176,242
1935	756,281,202	26,637,504	33,778,000	883,315	43,428,388	2,445,180
1937	936,047,208	35,672,363	9,380,472	287,927	60,449,922	3,247,357

/2 Source: United States Department of Commerce.
/3 Wheat starch, rice starch, and starches processed or packed from purchased stock.

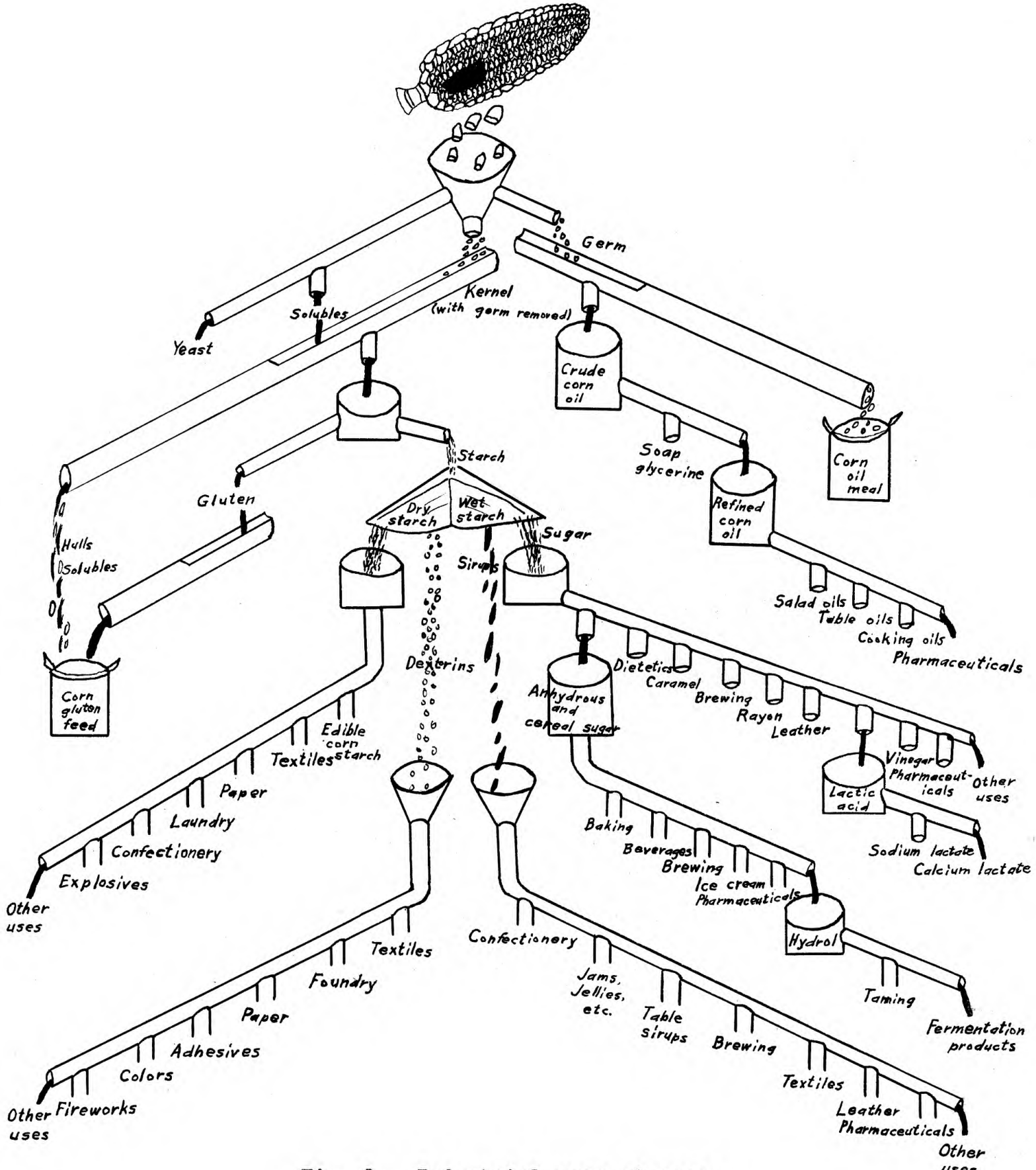


Fig. 1. Industrial uses of corn.

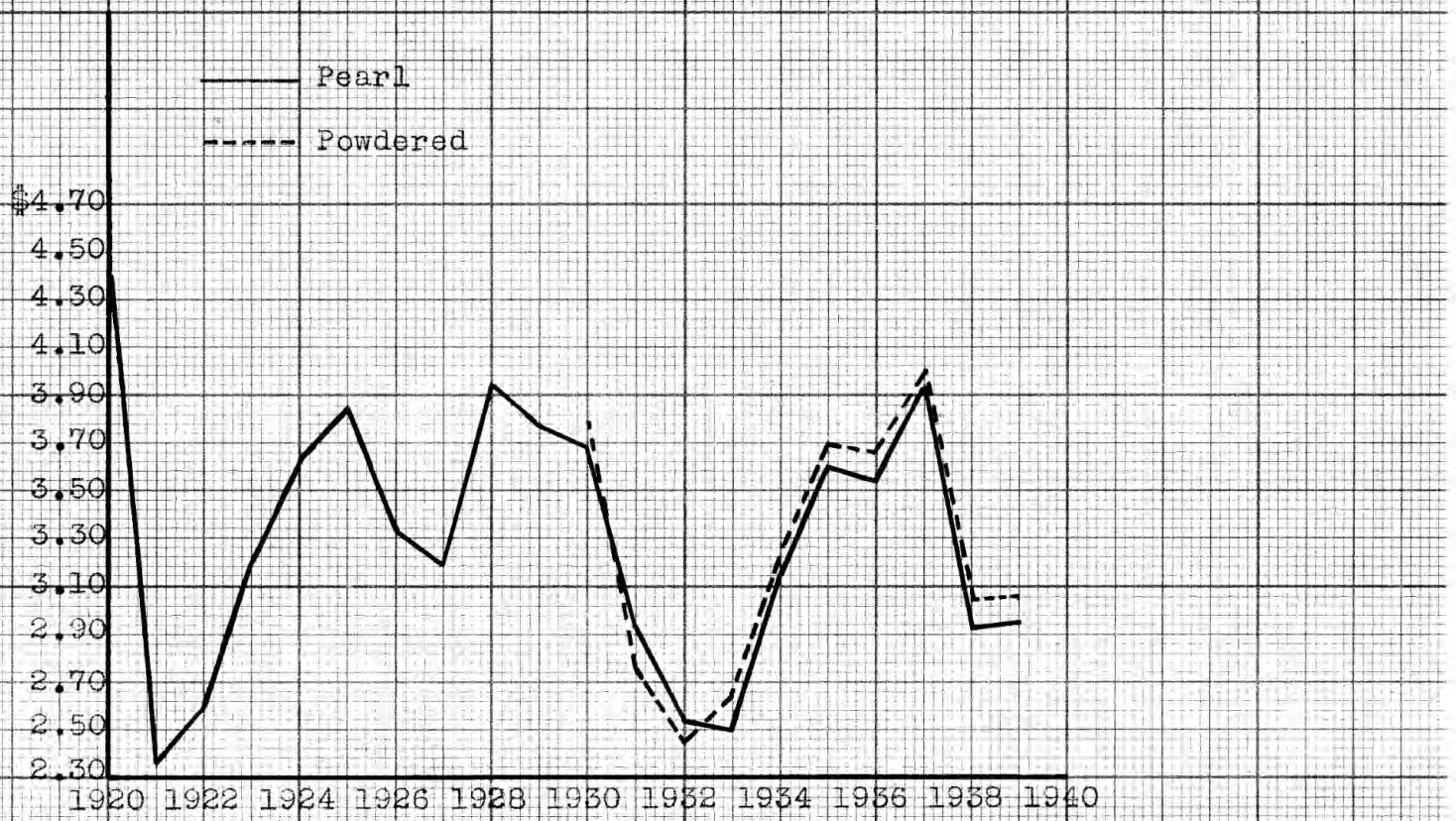


Fig. 2. Yearly average price of corn starch in 100-pound bags, New York City, 1920-1939 (33).

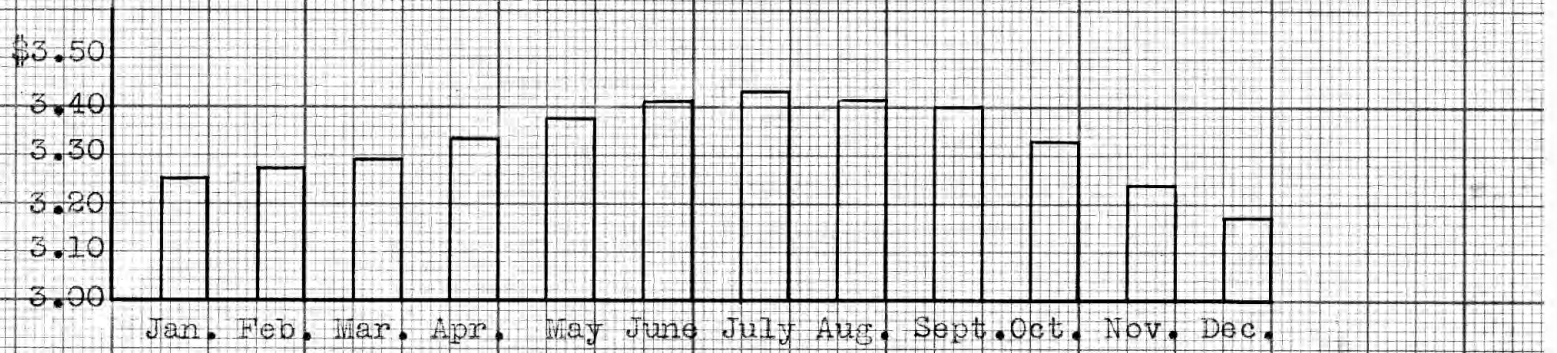


Fig. 3. Wholesale price of pearl corn starch, 100-pound bags. New York, 1920-1939 (33).

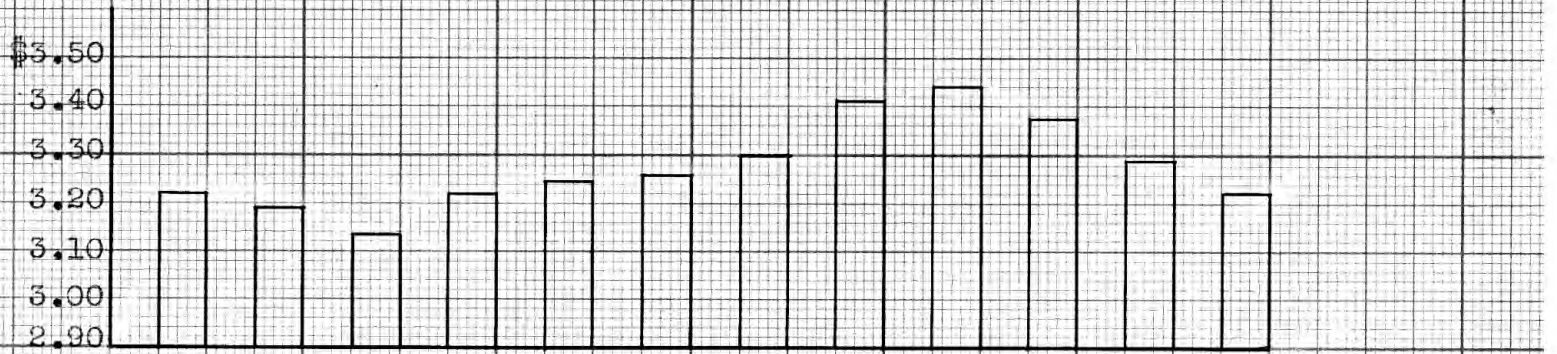


Fig. 4. Wholesale price of powdered corn starch, 100-pound bags. New York, 1929-1939 (33).

Table 3. United States imports of starches and farinaceous substances (45).

	1934	1935	1936	1937
Potato starch	13,621,506	8,386,900	12,669,565	10,528,187
Corn starch	133	640	63,568	270,992
Rice starch	741,454	359,046	676,927	954,971
Wheat starch	147,288	132,271	192,675	153,894
Other starches	6,406	21,680	74,989	54,516
Tapioca crude	4,210,382	1,934,440	6,292,907)	
Tapioca flour and prepared tapioca	171,899,003	200,177,879	263,210,802)	432,857,738
Sago crude	301,708	1,175,010	61,720)	
Sago flour	12,459,546	23,631,003	36,372,674)	33,469,945
Arrowroot starch and flour	3,610,193	4,511,846	4,526,844	5,281,910

considerable quantity of starch in this country if they compete with foreign producers.

An increase of tariffs on starch would tend to decrease the importation of root starches, and this would encourage the development of potato and sweet potato starch industries in the United States. The present import duty on white potato starch is 2.5 cents a pound. Holland, however, has a preferential duty of 1.75 cents a pound and supplies almost all of the potato starch imported into the United States.

At the present time, approximately one-half of the domestically-consumed potato starch is imported (Tables 2 and 3). The imported starch usually sells on the New York market for about 50 cents a hundred more than domestic potato starch (Fig. 5).

The Germans and Dutch have made more rapid progress in developing high starch-yielding varieties of potatoes and in improving their starch manufacturing technique than have manufacturers in the United States. They produce a higher-quality, whiter, more uniform starch at a cheaper cost than domestic manufacturers and, in past years, have been able to market a larger quantity of starch on the American market in spite of the tariff barriers.

There have been potato starch factories established in various places in the United States; but Aroostook County, Maine has been the only area in the United States where potato

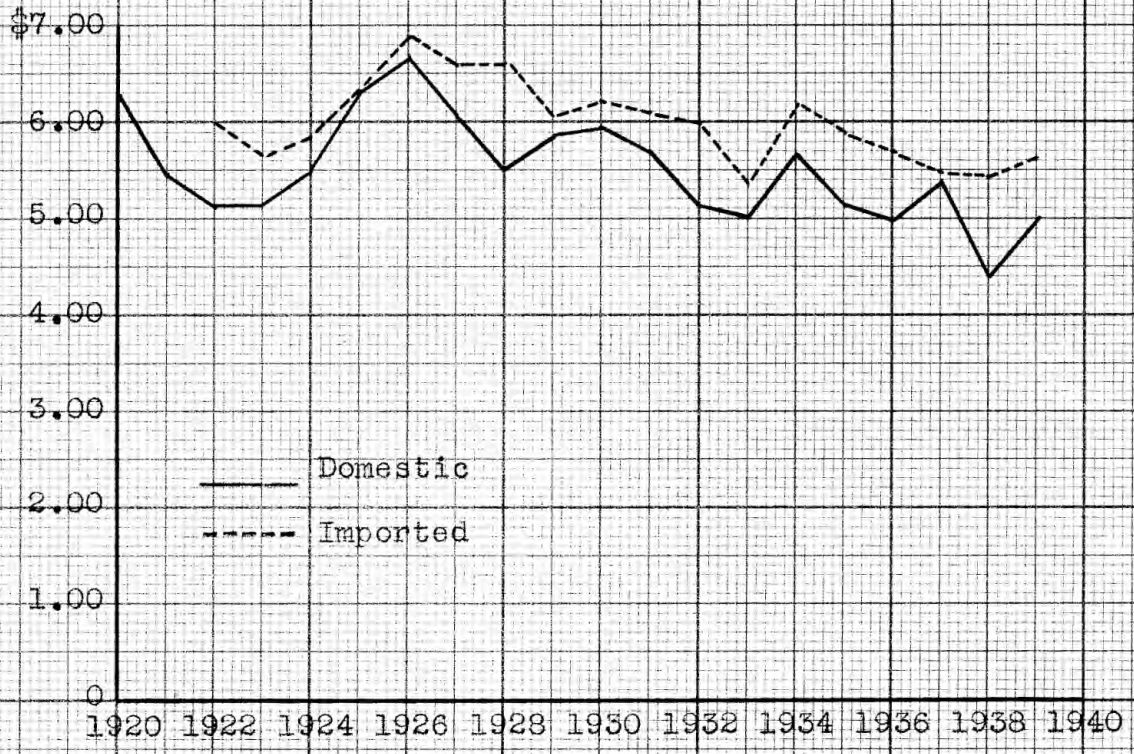


Fig. 5. Average annual price paid for 100 pounds of imported and domestic potato starch in New York, 1920-1939 (33).

starch factories have been able to operate successfully and on a large scale over a period of years. Today, Aroostook County is the only important potato starch producing region in the United States. There is a definite tendency among Maine potato starch producers to improve their methods of starch production and to develop more efficient factories. Two new, modern factories, much more efficient than the old-process factories, have been constructed in the last two years and several of the old factories have been remodeled and improved.

Potato starch may be referred to almost exclusively as a surplus commodity in the sense that it is produced in this country in volume only in those seasons when potato production is large and potato prices are low. In years of high prices for domestic potatoes, the proportion of imported starch is relatively large compared with those years of low domestic potato prices when the proportion of imported starch is relatively small. When potato prices are high, some of the potato starch factories are unable to operate and must close for the season. Starch production in Maine during a normal season commences during the potato harvesting season and, in most plants, ceases when severe weather sets in. Another period of operation then occurs in the spring and continues until May or June, depending upon the supplies of stored potatoes and certain physical factors such as water temperature, which affects the quality of the starch.

Potato starch prices have no definite seasonal trend nor do they vary much from year to year (Fig. 6). Because of the higher quality, imported potato starch usually sells for about 50 cents a hundred more on the New York market than does domestic potato starch. For the last several years, domestic potato starch has sold for about five cents a pound on the New York market although the price paid for the poorer grades of potato starch often has been below this, depending largely upon the quality of the potatoes from which it was extracted. Poor-quality, half-spoiled potatoes produce a poor quality starch.

Potato starch is used in a number of ways (Fig. 7). Its largest use, however, is in those industries requiring a good sizing material.

The sweet potato industry in the United States is a comparatively new industry, very little if any sweet potato starch having been produced prior to the development of the plant at Laurel, Mississippi. The output from this plant has grown fairly rapidly. In 1934, the output was 140,000 pounds and increased to an estimated 3,000,000 pounds in 1939 (Table 4).

Sweet potato starch can be used for almost any purpose for which any other root starch can be used. In the textile trade, it is superior to cereal starches as a sizing material.

In the past, most of the sweet potato starch imported into the United States has come from Japan where its manufacture is carried on as a small household enterprise. If the plant at

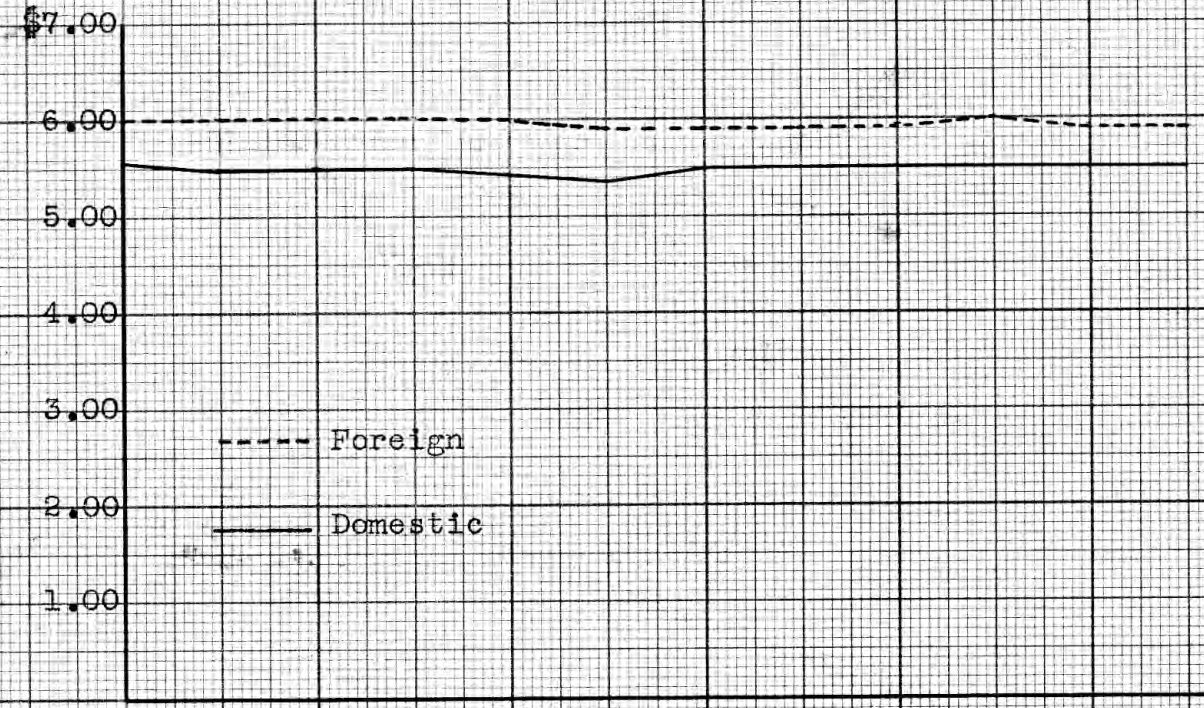


Fig. 6. Average monthly price received in New York for 100 pounds of domestic and foreign potato starch, 1920-1939 (33).

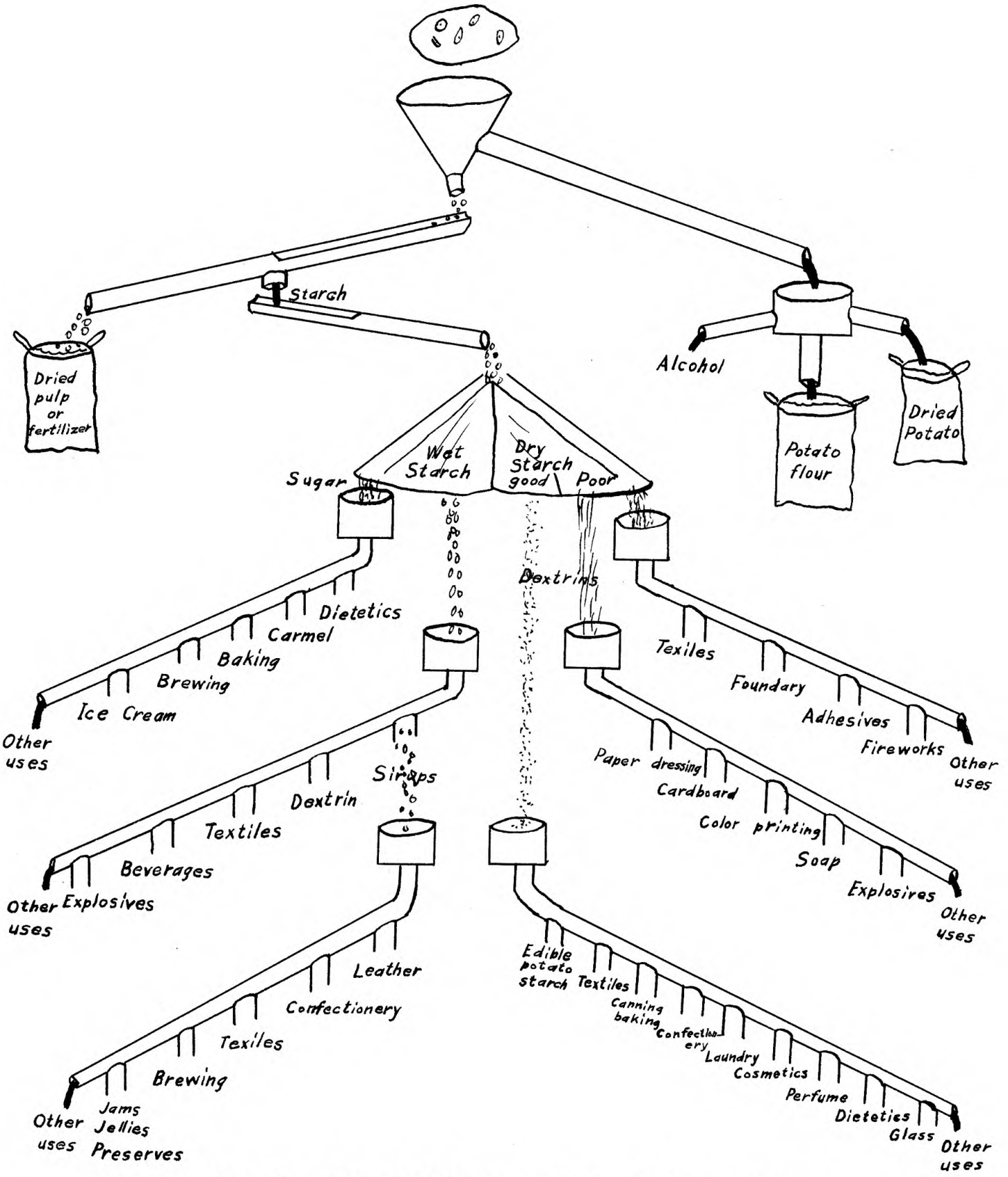


Fig. 7. Industrial uses of the Irish potato.

Laurel, Mississippi, proves to be as successful as the reports indicate, there possibly will be a considerable expansion of the sweet potato starch industry in this country.

Table 4. United States production of sweet potato starch (35).

Year	Production (1,000 pounds)
1934	140
1935	250
1936	420
1937	500
1938	1,700
1939	3,000

THE POTATO INDUSTRY IN KANSAS

Irish potatoes ranked third in importance in Kansas as a source of cash crop income during the 1925-34, ten-year period. They were surpassed by wheat and corn (Table 5). The 1923-34 period was used because it was felt that it portrayed a more normal group of years than 1930-39. However, the cash income from wheat and corn was considerably larger than the cash income from potatoes. Potatoes yielded only about 2 per cent of the total Kansas cash farm income from crops, while wheat and

corn yielded 69 and 12 per cent, respectively. Although relatively unimportant for the state as a whole, potatoes are an important cash crop in the counties of Douglas, Shawnee, Jefferson, Wyandotte, Johnson, Leavenworth, Pottawatomie, and Riley in the Kaw Valley. The relative importance of these counties in potato production and shipments is indicated in Tables 6 and 7. There are other counties in Kansas that produce potatoes on a commercial scale, but the Kaw Valley is by far the most important producing area (Fig. 8). Therefore, this study is limited to the Kaw Valley as far as the economics of starch production from Irish potatoes is concerned.

Table 5. Cash income from important Kansas farm crops, 1925-1934 (14).

Crop	Income/4 1925-34 average (000 omitted)	Per cent of total	Rank
Corn	$15,533	12	2
Wheat	89,959	69	1
Oats	1,564	1	5
Barley	1,195	1	6
Rye	180		8
Grain sorghum	1,599	1	4
Potatoes (Irish)	2,680	2	3
Potatoes (Sweet)	420		7
Total crop income	130,675		

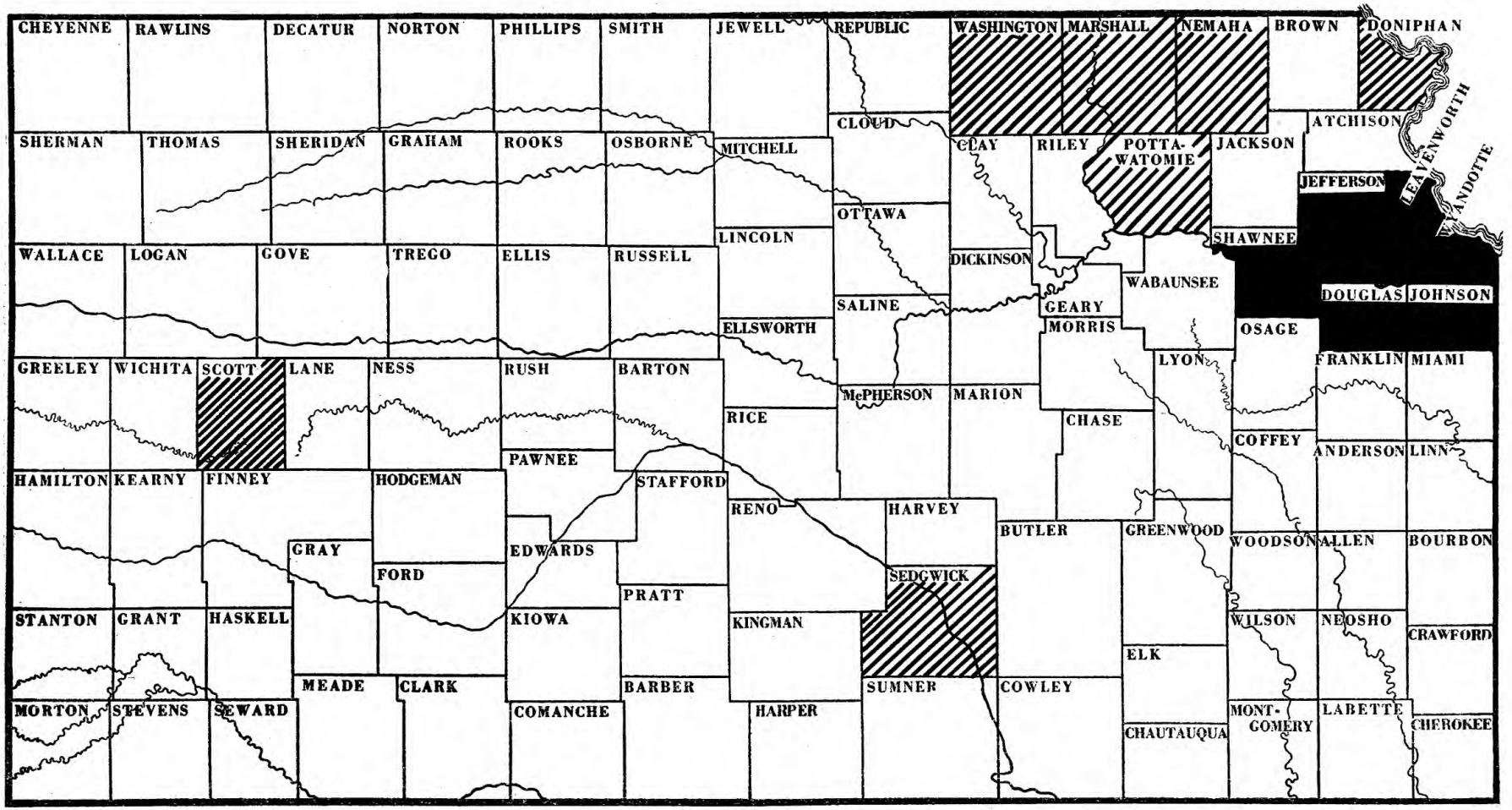
/4 AAA payments not included.

Table 6. Carlot potato shipments by important potato-producing counties in Kansas (13).

County	Number of cars shipped				
	1928-38 average	1935	1936	1937	1938
Douglas	767	259	587	669	982
Shawnee	596	130	241	200	329
Jefferson	287	63	84	108	152
Wyandotte	235	64	149	189	265
Johnson	165	50	100	110	249
Leavenworth	104	24	59	80	97
Pottawatomie	15	2	3	3	1
Scott	15	--	28	--	--
Reno	6	--	3	1	--
Riley	4	--	6	--	3
Total	2,194	592	1,260	1,360	2,078
Total for state	2,197	594	1,261	1,361	2,078

Table 7. Kansas potato acreage, production and yield per acre by important potato-producing counties, the Kaw Valley, and the entire state, 1925-38 (7,2).

Area	Acreage			Production (bu.) (000 omitted)			Yield (bu. per acre)		
	1925-38 average	1937	1938	1925-38 average	1937	1938	1925-38 average	1937	1938
Kansas	41,000	28,000	29,000	3,668	2,156	3,219	88	77	111
Kaw Valley	13,844	11,000	11,550	1,851	1,430	1,964	131	130	170
Shawnee	3,034	1,220	1,350	414	138	200	130	113	148
Douglas	3,158	2,930	3,120	402	340	493	125	116	158
Jefferson	1,857	1,155	1,270	266	112	187	119	97	147
Wyandotte	2,016	2,040	1,560	259	246	246	129	120	157
Leavenworth	1,704	1,410	1,800	211	143	267	120	101	148
Johnson	1,648	1,240	1,540	200	129	223	118	104	145
Scott	574	240	300	97	28	32	141	116	106
Doniphan	984	1,030	970	76	46	101	86	45	104
Pottawatomie	666	470	410	68	29	38	100	62	94
Riley	437	330	440	36	24	51	82	73	116



Less than 50,000 bushels 50,000 to 200,000 bushels More than 200,000 bushels

Fig. 8. Production of Irish potatoes in Kansas, 1925-38 (7).

The commercial potato industry in Kansas has declined in importance in recent years. During the eight-year period from 1923 to 1930, inclusive, the average annual carlot potato shipments from Kansas were 3,830 cars (Fig. 9). During the eight-year period 1931 to 1938, the average annual carlot shipments were 1,644 cars. This was an average decline of 57 per cent in the number of cars shipped annually. In 1937 and 1938 the number of cars shipped (per cent of the 1923-30 average) was 36 per cent and 54 per cent, respectively.

From 1920 to 1929 the annual potato acreage in Kansas averaged 54,000 acres. During the 1930 to 1939 period, the acreage harvested averaged 36,000 acres. This was a decline of 18,000 acres--33 per cent. The yield declined, on the average, about 10 bushels an acre during the two 10-year periods, and the annual average production declined from approximately 4,766,000 to 2,915,000 bushels.

The data on yield production and acreage for the Kaw Valley were not available in the U. S. D. A. Yearbook prior to 1922. However, the average annual potato acreage for 1922-29 for this area was 16,258 acres compared with 12,425 acres during the 1930-39 period. The decline in yield for the same period was from an average of 134 to 124 bushels an acre. Average annual production decreased from approximately 2,215,000 to 1,560,000 bushels during the two periods (Table 8).

Fig. 9. Carlot shipments of potatoes from Kansas, 1918-38 (42).

Table 8. Acreage, yield, and production of potatoes in Kansas and the Kaw Valley (2,3).

Year	Kansas			Kaw Valley		
	Acreage harvested (1,000 A.)	Yield (bu.)	Production (1,000 bu.)	Acreage (A.)	Yield (bu.)	Production (1,000 bu.)
1917	78	57	4,446			
18	80	53	4,240			
19	68	76	5,168			
20	60	85	5,100			
1921	65	64	4,160			
22	65	64	4,160	15,600	91	1,420
23	55	86	4,730	15,700	105	1,648
24	54	95	5,130	17,100	168	2,873
25	54	67	3,618	16,500	103	1,700
1926	43	91	3,913	15,800	157	2,481
27	49	110	5,390	17,300	145	2,508
28	50	150	7,500	18,160	193	3,505
29	44	90	3,960	13,900	114	1,585
30	42	114	4,788	14,300	180	2,574
1931	46	79	3,634	15,500	125	1,938
32	44	117	5,148	15,200	150	2,280
33	42	58	2,436	12,850	90	1,156
34	37	40	1,480	12,500	57	712
35	31	75	2,325	8,750	99	866
1936	30	57	1,710	10,500	117	1,228
37	29	77	2,233	11,000	130	1,430
38	29	111	3,219	11,550	170	1,964
39	29	75	2,175	12,100	120	1,452
Ave.	49	82	3,942	14,128	129	1,851
Ave. 1920						
1929	54	90	4,766	16,258/5	134/5	2,215/5
Ave. 1930						
1939	36	80	2,915	12,425	124	1,560

/5 1922-29 average.

Some of the more important reasons for the decline of the potato industry in Kansas and in the Kaw Valley may be listed:

(1) Increased supplies and competition from other areas, such as lower California--Kern County in particular. Kern County has increased its carlot potato shipments from less than 2,000 cars in 1932 to more than 13,000 cars in 1938.

(2) The price situation. Most of the potatoes in the Kaw Valley are harvested and shipped during the latter part of June and in July (Fig. 10). Usually, carlot potato shipments from the Kaw Valley begin during the last few days in June and are heaviest from July 1 to July 15. After July 15, the number of cars shipped daily decreases rapidly and there are only a few cars shipped in August and occasionally a few cars in September, October, and November. The largest percentage of these shipments is made just after a sharp seasonal decline in potato prices (Figs. 11, 12, and 13). The price usually increases in November and continues to improve until June. By July there usually is a seasonal price decline that continues through the season in which potatoes from intermediate and late potato producing states are marketed in large volume.

Kansas potatoes usually sell for less on the Chicago market than potatoes from competing areas. The average July price for Kansas cobblers on the Chicago market in July of 1937 and 1938 was $1.30 and $0.94. This compares with $1.89 and $1.71 for Idaho Russets and $2.28 and $1.88 for California White Rose

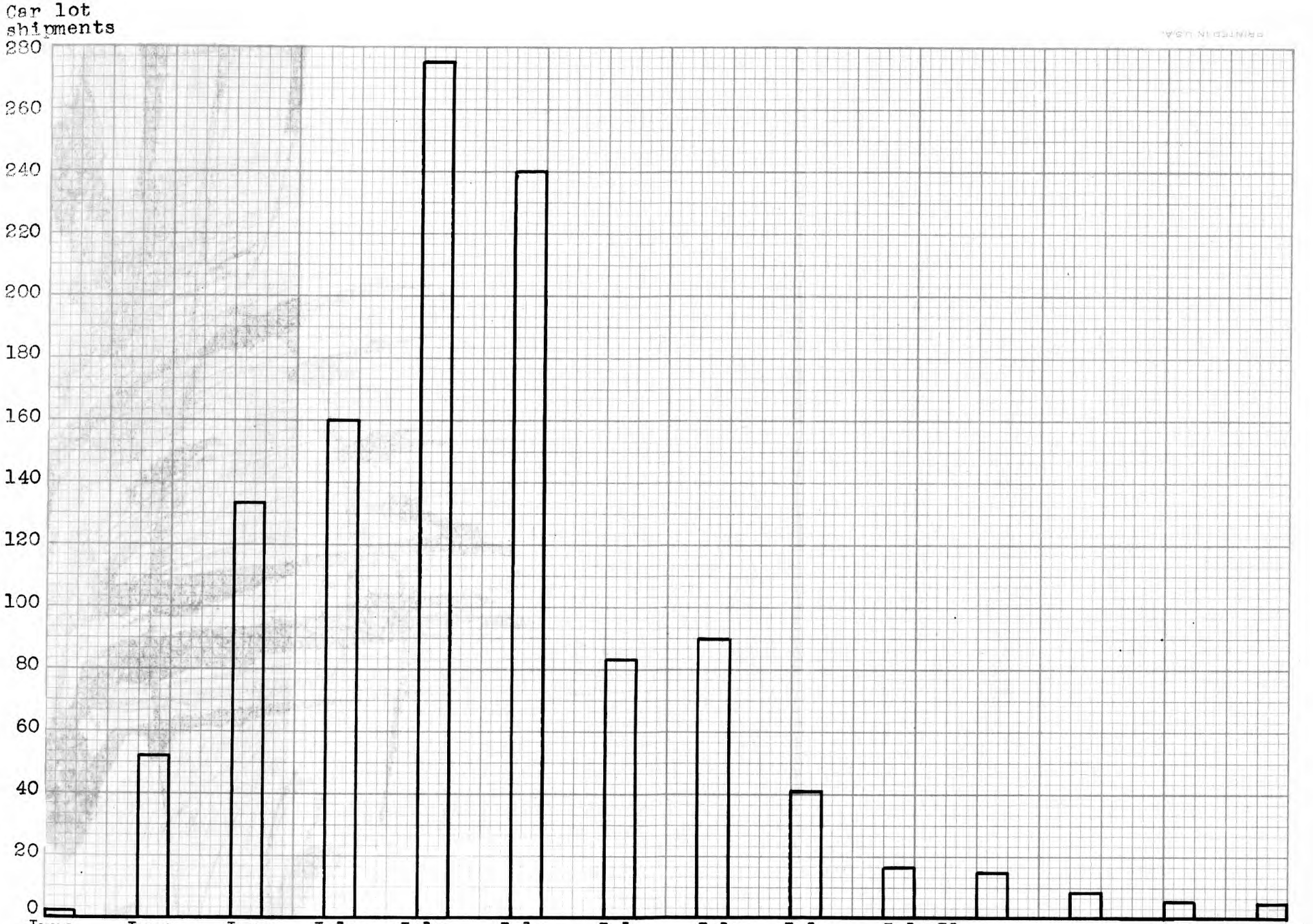


Fig. 10. Carlot shipments of Kaw Valley potatoes by five-day periods, June 15 to August 24, average, 1934-38 seasons (13).

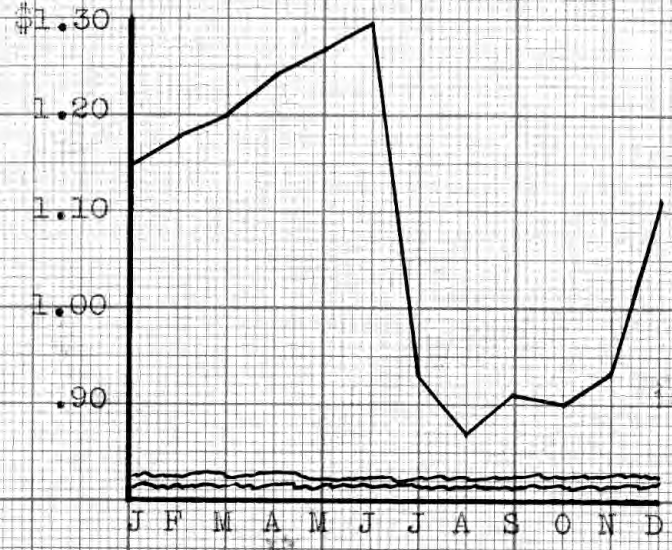


Fig. 11. Estimated price of potatoes received by producers in Kansas. Average monthly price based on 1926-1939 average (14).

Fig. 12. Price paid per hundred weight to growers on Kansas City curb market. Average 1931-1938 inclusive (28).

Fig. 13. Estimated price of potatoes received by producers in Kansas. Average price paid each year from 1926-1939 (14).

potatoes during comparable periods. This unfavorable price relationship for Kansas potatoes is true for other years (Fig. 14). Possibly this price discrepancy results, in part, from lack of attention to proper grading and conditioning potatoes for shipment.

(3) The quality of Kansas potatoes is influenced by climatic and pathological causes. Analysis of more than 3,000 federal potato inspection certificates indicates that, on the average, about 90 per cent of the cars inspected grade "commercial" or better. The other 10 per cent are in the No. 2 or unclassified group. However, only about 50 per cent of the cars shipped annually are inspected (Table 9). Since the fee for inspecting potatoes is $3 a car, it may be concluded that producers do not have their potatoes inspected unless there is a fair chance that the potatoes will grade "commercial" or better. There are no data available showing the quality of non-inspected potatoes.

Since nearly one-half of the days in the latter part of June and in July have temperatures of more than 90° F (Table 10) and since temperatures sometimes range 100° and more during this period, it is difficult to prevent heat damage and maintain good market quality. The Irish Cobbler, as grown in this area, seems to be particularly susceptible to potato scab and other skin diseases that detract from its market quality. There also is a high percentage of wire-worm injury and other insect damage.

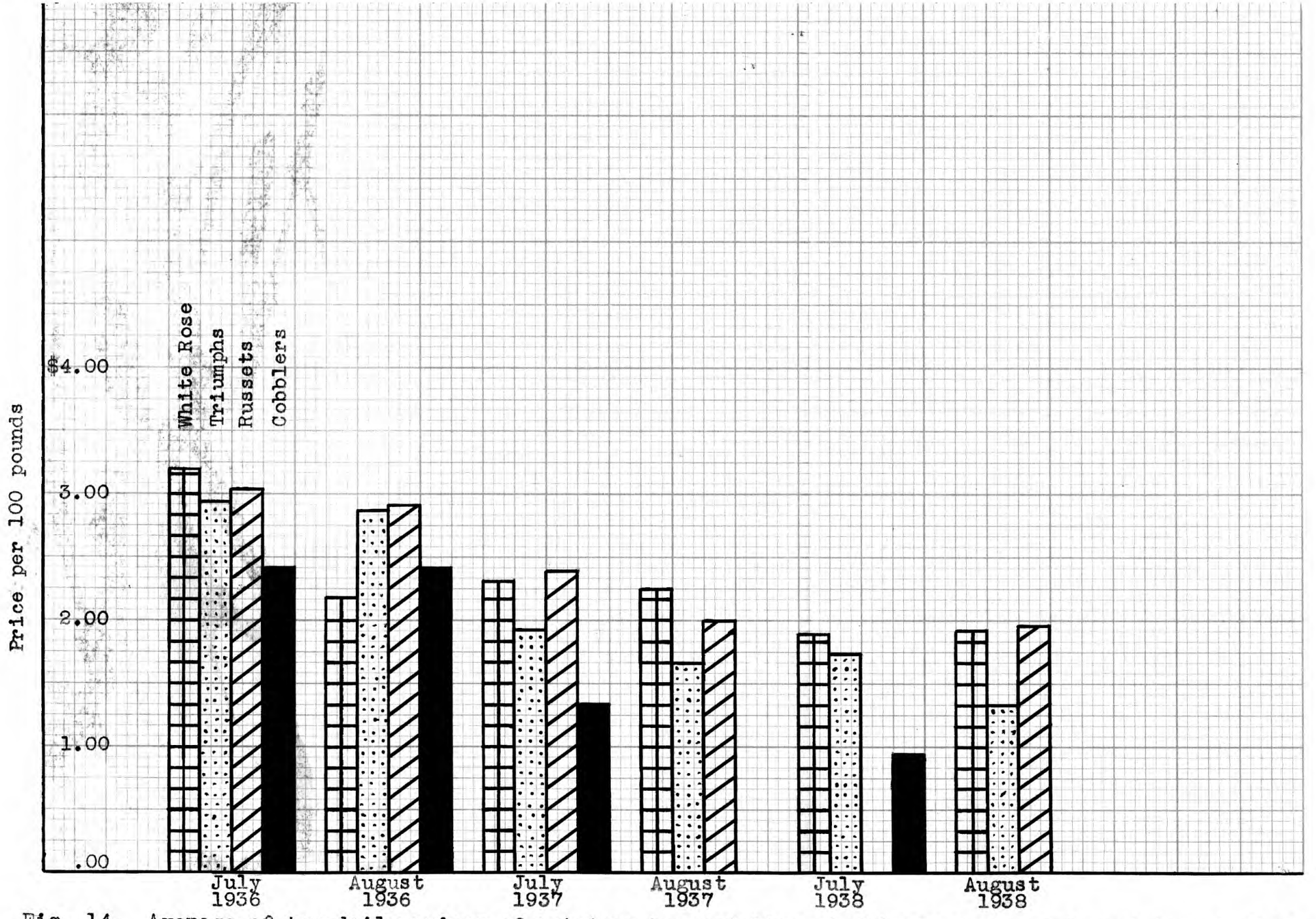


Fig. 14. Average of top daily prices of potatoes by varieties at Chicago during July and August, 1936, 1937, and 1938 (27).

Table 9. Potato carlot shipments, number inspected, and number of cars inspected grading commercial or better in Kansas, 1934-38/6.

Year	Annual carlot shipments	Carlots inspected		Carlots grading commercial or better	
		Number	Percent of annual shipments	Number	Per cent of cars inspected
1934	392	72	18	45	62
1935	595	233	39	204	88
1936	1,261	520	41	465	89
1937	1,361	640	47	621	97
1938	2,078	1,257	60	1,177	94

/6 Source: U. S. D. A. potato inspection certificates.

Table 10. Temperatures for June, July, and August at Topeka, Kansas, 1887-1930 (10).

	June	July	August
Mean	73.4° F	78.1° F	76.8° F
Average maximum	83.8°	88.7°	87.6°
Average minimum	63.0°	67.5°	65.9°
High	106.0°	107.0°	110.0°
Low	36.0°	50.0°	40.0°
Average number of days 90° or above	7	13	12

Because of the high temperatures during the potato marketing season, it is not commercially practical to store potatoes in common storage in the Kaw Valley. If potatoes are to be stored successfully, they must be placed in cold storage. Cold storage costs usually are 10 cents a hundredweight for the first month and five cents a hundredweight for each additional month. As a rule, not very large quantities of Kaw Valley potatoes are placed in cold storage since the seasonal price trend is downward during the storage season, making it difficult to regain storage costs.

Transportation costs vary in the Kaw Valley according to the method of hauling the potatoes. In a survey conducted at Topeka

among local, unlicensed truck haulers, it was found that the average rate charged by those truckers interviewed was a minimum of $2 a load for loads of 1½ to four tons for hauling any distance up to five miles. For hauling full loads, the average rate was 2.6 cents a hundredweight for five miles, four cents a hundredweight for 10 miles, 6.8 cents a hundredweight for 25 miles, and 10.5 cents a hundredweight for 50-mile hauls. The rates charged by several local haulers in Topeka are indicated in Table 11. This shows a fairly representative range of prices charged for hauling potatoes. The rate varies from season to season and apparently depends upon the availability of trucks at a particular time and the need of the trucker for employment at the time he is contacted for a job.

Minimum rates which the Interstate Commerce Commission permits railroad and licensed truck drivers to charge for hauling potatoes are indicated in Table 12. The truck rate, as set by the Commission, is considerably higher than the rail rate. For example, the truck rate from Manhattan to Topeka, Kansas, is 15 cents a hundredweight, while the rail rate for the same distance is only 10½ cents a hundredweight. The railroad rates for sugar beets from points in Kansas to Garden City, Kansas, are shown in Table 13. There are special rates allowed on sugar beets during the harvesting season when the beets are being concentrated at the factory. If a potato starch factory were established in the

Table 11. Local truck rates at Topeka, Kansas, as given by 10 truckers.

	Minimum for short hauls (Dollars) (per load)	Cents per hundredweight for hauling potatoes			
		5 mi.	10 mi.	25 mi.	50 mi.
(1)	1.50	1.5	4.0	6.0	10.0
(2)	2.50	1.6	3.8	5.0	9.0
(3)	--	2.0	3.0	5.0	8.0
(4)	2.00	3.0	3.0	6.0	10.0
(5)	--	3.0	4.5	6.0	11.0
(6)	--	6.0	6.0	11.0	15.0
(7)	--	2.0	3.0	6.0	8.0
(8)	2.00	3.0	5.0	8.0	12.0
(9)	2.00	1.0	3.0	5.0	7.0
(10)	--	3.0	5.0	10.0	15.0
Ave.	2.00	2.6	4.0	6.8	10.5

Table 12. Transportation rates for potatoes/7.

	Railroad carload rates (Minimum weight 36,000 lbs. from Sept. to May, incl. Minimum weight 30,000 lbs. during June, July and Aug.)	Contract motor carrier Minimum truckload rates Minimum weight 5,000 lbs.
	From Kansas points to Topeka, Kansas	From Kansas points to Topeka, Kansas
	(Hundred pounds)	(Hundred pounds)
Manhattan	10½ cents	15 cents
St. George	9½	14
Wamego	8½	13
Belvue	7½	12
St. Marys	7½	12
Rossville	6½	10½
Kingsville	6½	10½
Silver Lake	6½	10½
Kiro	5½	9½
Menoken	5½	9½
Ruby	5½	9½
Grantville	5½	9½
Newman	6½	10½
Medina	6½	10½
Perry	6½	10½
Williamstown	6½	10½
Buck Creek	7½	12
Midland	7½	12
Lawrence	7½	12
Bismark Grove	7½	12
Fall Leaf	7½	12
Linwood	8½	13
Fruitland	9½	14
Lenape	9½	14
Loring Quarry Spur	9½	14
Bonner Springs	9½	14
Sunflower	9½	14
Forest Lake	9½	14
Edwardsville	9½	14
Muncie	9½	14

/7 Source: Topeka traffic association.

Table 13. Railroad carload rates on sugar beets from points in Kansas to Garden City, Kansas/8.

For distances	Minimum weight, 60,000 pounds
Not over 10 miles	32¢ Net Ton/9
Over 10 miles but not over 15 miles	37¢ Net Ton/9
Over 15 miles but not over 20 miles	42¢ Net Ton
	Minimum weight, 45,000 pounds
Over 20 miles but not over 40 miles	2 3/4¢ Cwt.
Over 40 miles but not over 60 miles	3 1/4¢ Cwt.
Over 60 miles but not over 100 miles	3 3/4¢ Cwt.
Over 100 miles but not over 150 miles	5 1/2¢ Cwt.

/8 Source: Topeka traffic association.
/9 If charges based on actual extension are less than $12.10 per car, the charge per car to be assessed will be $12.10.

Kaw Valley, similar rates probably could be established for potatoes if there were a large enough volume to warrant them.

Questionnaires were mailed to 100 of the leading Kaw Valley potato producers to determine just what proportion of the poorer grades of potatoes should be kept from the market, in what manner these poor-grade potatoes should be disposed of, and what the growers should be compensated per bushel for keeping them from the market. Twenty-four questionnaires were returned with the following information: Twenty potato growers felt that there was a need in the valley to dispose of low-grade potatoes outside regular market channels, one said there was a need at times, two gave no answer, and one said that

there was no such need. Regarding the question of whether or not growers would enter into contract agreements to deliver all potatoes below a certain grade to a factory, if it were economically advisable to establish one, 17 answered yes, two were doubtful, one said that some would, and one said that it should be compulsory.

As to what grades should be kept off the market and destroyed or sold to a factory at prices from 10 to 25 cents per hundred pounds, four growers said any below U. S. #2, four said any below commercial, seven said only culls and throwouts, four gave no answer, one said any below 60 per cent U. S. #1, one said any below 80 per cent U. S. #1, and two said any below 1 3/4-inch minimums. The answers to this question are quite significant in that they show that producers, in general, were not familiar with potato grades and that most of them would be willing to dispose of their otherwise non-marketable potatoes at a price of 10 to 25 cents per hundredweight.

The answers to the question of what percentage of the potato crop producers would be willing to divert from regular market channels at the above prices ranged from 3 to 25 per cent and averaged 11 per cent, which is close to the United States Department of Agriculture estimate that about 11.9 per cent of the potatoes produced in the United States are culls.

Another interesting fact was the answers to the question, "If a potato starch manufacturing concern is established, should

it be cooperative or a private enterprise?" Nineteen growers preferred private enterprise, three preferred a cooperative organization, one said that there was no difference, and one gave no answer.

POTATO STARCH FACTORIES IN THE UNITED STATES

At the present time there are 28 potato starch factories in the United States, of which 27 are in Maine in the county of Aroostook and one is at Dalbo, Minnesota. Most of these factories are old and a few probably will never operate again. Of the 27 Maine plants, there are two new factories with modern machinery and equipment, and a few of the older plants have been modernized to a greater or lesser degree. The new plants have a much larger capacity and achieve a higher extraction rate with lower per-unit costs than do the older-type plants. The old-type factories produce from one to ten tons of starch a day during the operating season.

Old-Process Method of Extracting Potato Starch

Correspondence with potato starch factory operators and with some of the personnel of the United States Department of Agriculture indicates that practically all of the Maine starch factories have been operating on what is known as the "American System", which involves very simple buildings and equipment. In most cases, nearly all of the equipment can be installed by

a competent millright. The process is as simple as the equipment. When possible, the factories are located on the bank of a river and are of two-story construction, the upper floor being at the ground level to facilitate unloading. The potatoes are unloaded into a hopper, from which they fall by gravity into a washer. In the washer they are agitated with water to remove most of the dirt and other foreign material. From the washer the potatoes proceed to a rasp grater where skins and all are reduced to a pulp. The potato pulp passes from the grater to an inclined canvas-covered screen. Streams of cold water playing on the screen leach out the major part of the starch content of the potatoes, and the pulp then falls into a drain and is washed into the river. The starch-bearing water is then pumped into vats, which may be either concrete or wood. After settling, the water is pumped off, the sediment or dark material is scraped off, and the starch residue is agitated with fresh water in a washing process. This washing may be done from one to five times, depending upon the purpose for which the starch is to be used and the care which the individual manufacturer wishes to take.

Under ordinary circumstances in starch manufacture, when the weather and the water used in the process are cold, deterioration of the starch milk due to fermentation is not excessive; but in the late fall and early spring, fermentation is

found to be very costly. In fact, several factories recently have begun the practice of adding sulphur-dioxide to the starch water as it leaves the screen. The sulphur-dioxide reduces fermentation and bacterial action and usually produces a whiter starch.

After the final washing, the starch is pumped into a finishing tank and allowed to settle. After settling, the water is pumped off and the remaining starch, pasty but quite solid in form, is elevated to the drying room where it is dried at temperatures ranging from 120° to 160° Fahrenheit. Most of the drying rooms are constructed with slatted floors, with spaces approximately an inch wide. When the starch has been thoroughly dried, it is crushed finely enough to pass between the slats into bins on the floor below. The manufacturing process is then complete. The roughly crushed starch may be packed and sold in the lump or pearl form, or it may be milled to a powdered starch. There is no difference between these three types of potato starch, except in appearance and the size of the lumps.

New Continuous Process Method of Extracting Potato Starch

In the new or so-called continuous process factory, the potatoes are passed over iron grates when they are dumped or unloaded. A large part of the dirt and other impurities falls

through and is removed before the potatoes enter the factory. From here the potatoes roll into concrete storage cellars. From these cellars they are allowed to pass by regulated bin openings into conveying troughs which are usually constructed of concrete. When sufficient water is passed through these troughs, the potatoes are carried into the washing machines where they arrive with little adhering dirt. At the washer, the potatoes are completely washed and the remaining dirt is removed. A thorough removal of dirt is necessary to obtain a good quality of starch. The potatoes are then fed at a regulated speed into the rasp where the potatoes are pulverized, skin and all. Chemicals are added to the pulp and it is pumped to cylindrical brush and shaking sieves where a greater part of the starch granules are removed. After a large part of the starch has been removed, the pulp is again submitted to further disintegration, usually by means of a burr-type mill. The finely ground pulp is again sieved and the pulp, after this second sieving, is washed into the river. The starch milk from the sieves is pumped to a centrifuge where the starch is separated from the protein water.

When the starch comes from the centrifuge, it is resuspended in water and again sieved, this time through fine meshed sieves. Then it is submitted to further chemical treatment and is further refined through the process of tabling. It is then partially dried by centrifugal or vacuum filters and passed through rotary belts or rotary driers. The dried starch is

pulverized, sifted, and placed in 200-pound paper-lined burlap bags.

Economic Requirements of a Modern Starch Factory

There are little, if any, data available as to the actual costs of potato-starch production which show specific costs such as wages, rent, interest, etc. The data presented here are a summary of materials secured through correspondence with men who have had considerable experience with potato starch factories. The processing cost per pound of starch is considered to be approximately one to two cents a pound. This, of course, will vary with the efficiency of the plant, the quality of the starch produced, and the individual plant's requirements of selling, overhead costs per unit, packaging, loading, transportation and other marketing costs.

The Federal Surplus Marketing Corporation allowed the starch factories in Aroostook County, Maine, (based on a marketing study of 1938) a total processing margin of 1½ cents a pound, f.o.b. factory basis. Of this, one cent was understood to include labor, fuel, depreciation, bagging, taxes, and other charges exclusive of selling costs. One-fourth cent was allowed for powdering and bolting. Brokerage charges accounted for about one-fourth cent a pound and the freight to New York (500 miles) was about one-half cent a pound.

Potato starch manufacturers expect to obtain about 12 pounds of starch from 100 pounds of potatoes, although it seems to be a common idea that 10 pounds of potatoes are required to produce one pound of starch. Probably this one-to-ten ratio should be applied to cull potatoes, as the better-grade potatoes usually give higher starch yields. Starch yields from potatoes grading U. S. No. 2 or better should average about 13 to 14 pounds a hundred and the modern process should yield two to five pounds more.

As far as could be determined, none of the potato starch factories in Maine makes use of the waste potato pulp. This is due primarily to the fact that the cost of dehydrating and preparing the pomace for shipment would be excessive in that area. There is a possibility, however, that if the factories were in proximity to a livestock feeding area, the waste pulp could be utilized for stock feed. According to literature from there, waste water from the starch factories in Germany is used for fertilizer and irrigation. However, there is little information available as to the cost of dehydrating and processing the pulp, its comparative feed value, or as to the value and cost of applying waste water for irrigation and fertilizer purposes. For that reason, waste material from potato starch factories will be considered of no value in this study, regardless of the fact that various methods of utilizing the waste pulp might prove to be economical in the future.

To be practical, a modern starch factory for the complete manufacture of a high-quality starch should have a capacity of at least 10 tons of finished starch a day. A 10-ton potato starch factory of the modern type requires a fixed capital of about $75,000 for land, buildings, and equipment. The amount of working capital required usually is about $10,000. This will vary, of course, according to the amount of money that needs to be invested in potatoes between the time the raw potatoes are bought and the time the finished product is placed on the market. If it is necessary for the factory to buy large quantities of potatoes at the beginning of the season to be assured of a volume large enough for operation the entire season, or if it is necessary to store a large quantity of the finished product before it can be placed on the market, the working capital necessarily will be larger.

The old-type plants can be built with about one-half the cost of a modern factory. However, due to the fact that modern plants turn out a much higher quality of starch with more efficiency, construction of an old-style plant probably would not be practical.

Personnel requirements vary according to the capacity of the plant, quality of the starch made, procedures of manufacture, location of the plant, and other factors. Employees for a 10-ton per day plant number from 10 to 25, with 12 to 15, 1½ men

per ton of starch processed per day, in the usual plant. It appears to be the custom to move the crew from one operation to another, depending upon the status of the batch in process rather than to have enough men to complete all of the operations at once.

To be able to compete in starch manufacture, the factories should be able to operate at least 100 days a year, on the average, to reduce overhead and fixed costs per unit. As far as can be determined, there are no alternative uses for potato starch factories; therefore, it is important that they be developed only in areas where, on the average, there are enough potatoes grown to supply a factory for at least 100 days.

THE ECONOMIC ASPECTS OF THE POTATO STARCH INDUSTRY IN KANSAS

If a potato starch factory were to be established in Kansas, it probably would have to be a complete unit capable of producing a finished product of at least 10 tons of starch a day. There are some small factories in Germany and Maine that produce a partially-processed, wet starch which is sent to larger factories for further refining and drying. However, the Kaw Valley is so far from any other potato starch factories that the cost of shipping partially-processed, wet starch for further refining probably would be excessive. Furthermore, other potato starch factories in the United States are idle during the time of the

year when potato starch would be produced in the Kaw Valley.

The fixed capital and equipment cost of building a modern starch factory is estimated at approximately $75,000. Such a factory should have a visible supply of raw material large enough for at least 100 days operation a year to reduce overhead costs per unit to a competitive level.

Probably the first step in deciding whether or not a potato starch factory could be established economically in Kansas is to determine what prices could be obtained for the finished product.

Domestic potato starch of the better grades averaged about $5.16 a hundred pounds on the New York market for the nine-year period from 1931 to 1939 (Fig. 5). At the present time, domestic starch is selling for about $6 a hundred pounds on the New York market and perhaps will go higher than at present (July, 1940) if the European war continues for any length of time. War, however, has only a temporary effect on prices, so calculations made herein are based upon prices during more nearly normal periods.

Over a period of years, potato starch manufacturers in Maine have been receiving about two to five cents a pound for potato starch at their factories, depending upon the quality. The marketing costs in Maine are about one-quarter cent a pound brokerage fee and about a half a cent per pound freight to New York City (500 miles).

The only indication of what price could be obtained for potato starch manufactured in Kansas is a comparison of wholesale corn starch prices in Kansas with wholesale prices in New York.

Corn starch for household consumption is sold on a ship-in basis in Kansas, according to wholesale prices received in Topeka. Prices for various trade-marked and bulk starches are shown in Fig. 15. The last year for which it was possible to secure wholesale quotations on starch sold in Topeka or any other point in Kansas was 1934. During the 1930-1934 period, Stanley corn starch sold for an average price of 5.8 cents a pound, Argo corn starch, 7.1 cents; Kingsford corn starch, 11.2 cents; Buffalo corn starch, 3.9 cents; and powdered bulk starch, 6.4 cents a pound. Stanley, Argo, and Kingsford are all trade-marked starches and the price given is the quotation for cartons containing 48 one-pound packages. Buffalo starch is sold in 140-pound bags and quotations were given for powdered bulk starch only in 1931.

Corn starch, both powdered and pearl, sold for about three cents a pound (Fig. 2) during this period on the New York market. No data could be obtained as to the items that make up the price differential between the New York price for corn starch and the price of wholesale starch in Topeka, Kansas. However, the price of bulk starch indicated that the price for corn starch in Kansas is equal to, or above, New York prices. If a potato starch industry were developed in Kansas, the produce probably

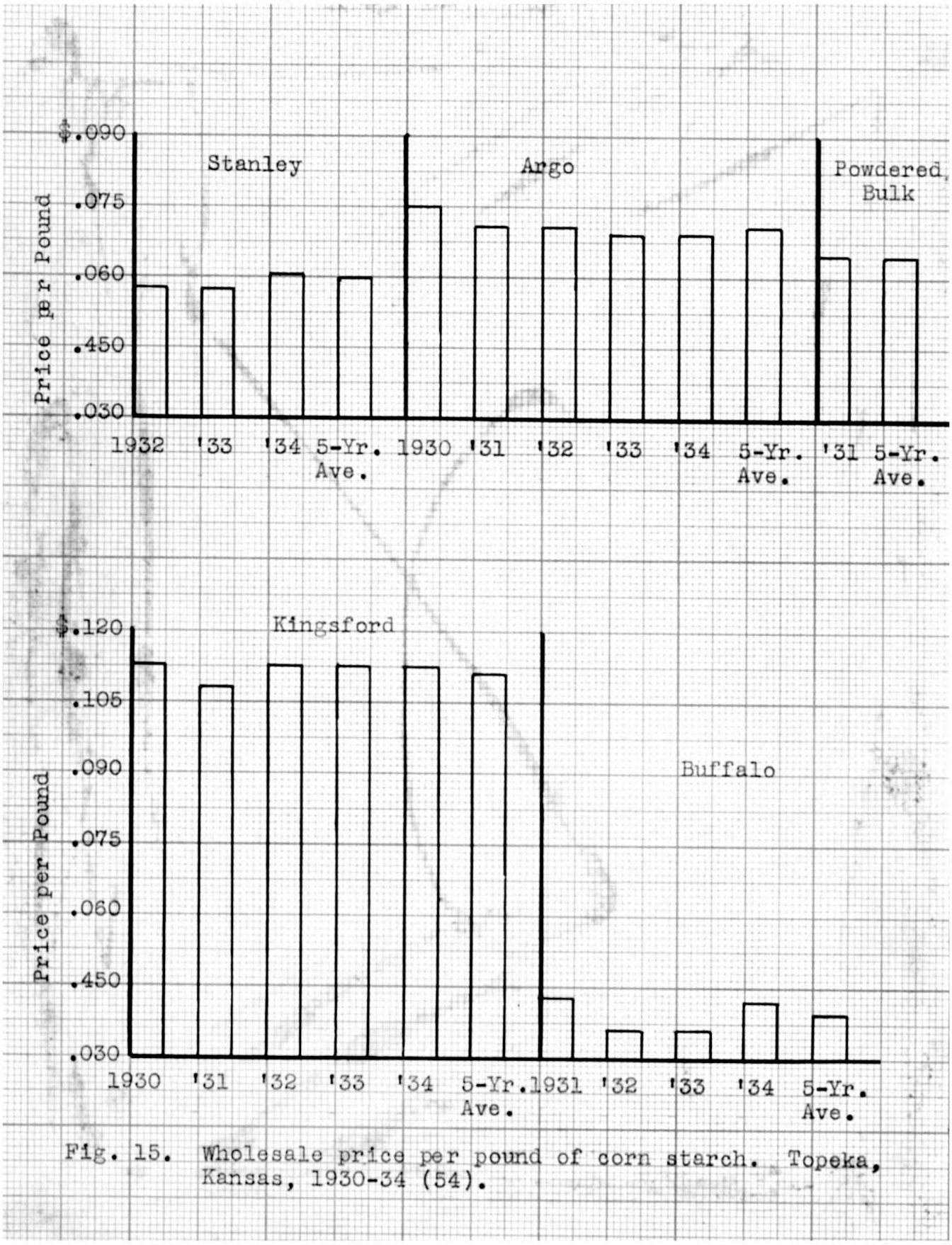


Fig. 15. Wholesale price per pound of corn starch. Topeka, Kansas, 1930-34 (54).

could be sold on a market closer than New York at a price equal to or above the New York price. However, any price received probably would be based on the New York market and any price differential would depend partly upon the saving in transportation costs. Since the potential output from a Kansas potato starch factory would be relatively small, selling and distributing costs probably would be higher than in Maine where the volume is large and a marketing system has been established. An estimated marketing cost for potato starch from Kansas probably would be approximately one cent a pound. However, Kansas manufacturers of potato starch should be able to receive about four to five cents a pound, f.o.b. factory, for good-quality starch.

A new, modern-equipped starch factory should be able to procure about 15 pounds of starch from 100 pounds of potatoes grading U. S. No. 2 or better. With starch selling at four to five cents a pound, the finished product from 100 pounds of potatoes grading U. S. No. 2 or better would be worth from 60 to 75 cents a hundred. Processing costs would be about one cent per pound of starch produced, or 15 cents per 100 pounds of potatoes processed. Potatoes then would be worth 45 to 60 cents a hundred, or 27 to 36 cents a bushel at the factory. The basis for determining the price a starch factory would have to pay for good-grade potatoes to divert them from the regular market channels is the United States Department of Agriculture's estimated

price which farmers receive for potatoes. This price usually includes the cost of sorting and sacking. As potatoes to be processed into starch would not necessarily need to be sacked or sorted, these costs should be taken into consideration.

Potato growers in the Kaw Valley usually pay about 7.5 cents each for their sacks, and sorting costs are approximately two cents a hundred pounds. Together, these costs are roughly 10 cents a hundred--six cents a bushel.

Therefore, with 36 cents a bushel being about the maximum price that starch factories could afford to pay for potatoes, the market price would have to be 42 cents a bushel or less before the factory could obtain good potatoes for processing. During the 14-year period from 1926 to 1939 (Table 14), there were only three years when the average annual price which farmers received for potatoes was below 42 cents a bushel at any time during the period when most of the Kaw Valley potatoes were marketed.

Thirty-six cents a bushel is probably the maximum price that could be paid for good potatoes at the factory but from this, transportation costs from the farm must be deducted. However, transportation costs probably would not be a large item if enough potatoes were to be hauled to the factory so that reduced rates could be obtained. Since there have been so few times in the last 14 years that a starch factory could obtain good potatoes at prices it could afford to pay, there probably will be only

Table 14. Estimated price per bushel of potatoes received by producers in Kansas during June, July, and August, 1926-1939 (14).

Year	June	July	August
1926	2.50	2.00	1.40
1927	2.20	2.00	1.50
1928	1.25	.70	.55
1929	1.00	1.20	1.25
1930	1.90	.80	.85
1931	1.20	1.05	.80
1932	.80	.40	.35
1933	.85	1.30	1.55
1934	1.05	.60	.85
1935	1.10	.33	.40
1936	1.75	1.25	1.20
1937	1.20	.55	.65
1938	.55	.33	.25
1939	.75	.60	.60

occasional years in the future when a potato starch manufacturer could obtain potatoes grading U. S. No. 2 or better at this low price. A potato starch factory in the Kaw Valley undoubtedly would have to depend upon poor-grade and cull potatoes for its supply of raw material.

Even a modern starch factory probably could not extract much more than 10 pounds of starch from 100 pounds of poor-grade or cull potatoes. Assuming that the factory were completely modern and could obtain a good quality of starch from poor-grade potatoes--which is a liberal assumption--100 pounds of poor-grade potatoes would yield from 40 to 50 cents worth of starch. For poor-grade potatoes, the processing cost probably would be about 1.5 cents a pound of starch produced or 15 cents a hundred pounds. This would mean that a starch factory could pay from 25 to 35 cents a hundred, or from 15 to 21 cents a bushel, at the factory for poor-grade potatoes. If the starch factory were established at Topeka or Lawrence, transportation from any local shipping point in the Kaw Valley (between Manhattan and Kansas City) probably would not exceed 10 cents a hundred pounds, provided a private hauler could be contacted (Table 11). If special freight rates could be established, comparable to rates on sugar beets at Garden City, the transportation from any point in the Kaw Valley probably would not exceed five cents a hundred pounds. Thus, if the volume of potatoes were large enough to warrant the establishment of a starch factory in the Kaw Valley, the

transportation costs probably could be adjusted so that almost any producer between Manhattan and Kansas City could profitably ship his cull potatoes by rail to a starch factory at Lawrence or Topeka, provided rapid deterioration of the potatoes was not a limiting factor.

A 10-ton starch factory that could recover 10 pounds of starch per 100 pounds of cull potatoes would require 100 tons of potatoes a day to produce 10 tons of starch. A supply of 10,000 tons of potatoes would be necessary to keep such a factory in operation 100 days. There are 333,000 bushels in 10,000 tons--20,000,000 pounds. Thus, about 350,000 bushels of potatoes would have to be available annually for a 10-ton potato starch factory to operate 100 days.

The prices for good potatoes are too high, normally, for a starch factory to process them economically. Therefore, any potato starch factory established in the Kaw Valley would necessarily have to use only cull potatoes for starch production in most years.

During the 1922-29 period, the production of potatoes in the Kaw Valley averaged 2,215,000 bushels and during the ten-year period, 1930-1939, was only 1,560,000 bushels (Table 8). According to questionnaires mailed to growers, approximately 11 per cent of the potatoes of the Kaw Valley could be diverted to a starch factory, 10 to 25 cents a bushel being the estimated price the growers would obtain at the factory. The growers' estimate

of 11 per cent culls closely approximates the United States Department of Agriculture's estimate of 11.9 per cent culls for the United States as a whole. Thus, it may be assumed that about 10 to 12 per cent of the total production of potatoes in the Kaw Valley would be available for starch factories at prices they could afford to pay. Twelve per cent of 1,560,000--187,000 bushels--would be about the maximum average volume of cull potatoes that would have been available annually for starch production from 1930 to 1939. This would operate a 10-ton starch factory about 56 days, or about half the time necessary to operate successfully on a competitive basis. Even with the larger production during the 1922-29 period, there would have been only enough cull potatoes to have operated a 10-ton starch factory about 85 days. As far as could be determined, there were no alternative uses for a potato starch factory. If it were possible to develop alternative uses for potato starch factories during their periods of idleness, the volume of potatoes required annually to cut down overhead costs could be reduced.

From the foregoing data, it may be concluded that with the present technique in starch production and with the present volume of potato production in the Kaw Valley, it would not be economically advisable to establish potato starch factories in Kansas. The major limiting factors are: (1) Potatoes grading above U. S. No. 2 or better are too valuable as human food in normal years

to be used in starch manufacture. (2) With present acreage and production, the supply of cull potatoes is not large enough to provide a sufficient quantity of raw material to operate the minimum-capacity starch factory recommended for the minimum number of days a year.

While these factors are the principal and most apparent reasons why a starch factory would not be advisable in Kansas, there are other factors that would seriously hamper, if not limit, the establishment of starch factories in Kansas. Because of hot summer temperatures, most of the potatoes are harvested and placed on the market during a 60-day period from June 15 to August 15, the largest part being marketed in the early part of July. A starch factory probably would have to start operation as soon as the potato harvest began and, to have a large enough supply for a season's operation, a considerable quantity would have to be stored. Cold-storage costs usually are 10 cents a hundred for the first month and five cents a hundred for each additional month. This soon would amount to more than the value of the potatoes. Because of the high temperatures during the Kansas potato marketing season, common storage for any length of time is considered impractical as the potatoes--particularly those of poorer quality--would spoil.

Another serious handicap would be excessive fermentation of the starch milk in the manufacturing process during the hot

summer months. At the present time, Maine potato starch manufacturers process most of their potatoes during the fall and early spring. At that time of year, fermentation in Maine is not a major problem. By using clean, cold, well water in the manufacturing process, fermentation can be reduced and a cleaner starch can be produced. Those factories that have been extending their operations over into the late spring have been using sulphur dioxide to prevent fermentation. Perhaps, with the use of sulphur dioxide and other chemicals, it would be possible to operate a potato starch factory during the hot summer months in Kansas. However, fermentation probably would be a problem and would interfere with the process to a greater or lesser degree as well as adding to the expense of operation.

Any method of disposing of the poorer grades of Kaw Valley potatoes or removing them from the regular market channels probably would be of great benefit to the producers in that they would receive a higher price for the potatoes of better quality. However, considering present manufacturing technique and production trends in the Kaw Valley, establishment of a potato starch factory apparently would be a risky and uncertain business venture.

STATUS OF THE SWEET POTATO INDUSTRY IN KANSAS

Sweet potatoes are produced to a greater or lesser degree in nearly every county in Kansas (Fig. 16). Wallace, Greeley, Wichita, Grant, Haskell, Morton, and Stevens counties are the only counties that did not produce any sweet potatoes during the 1925-38 period. There are three areas in Kansas where the production in each county for the 1925-38 period averaged more than 10,000 bushels a year. The largest area, in order of volume produced, is the Kaw Valley district which includes Shawnee, Wyandotte, Dickinson, Johnson, Riley, and Wabaunsee counties (Table 15). The second largest area includes Sedgwick and Reno counties, and the third largest is Finney county.

From a commercial standpoint, Kansas is not an important producer of sweet potatoes, most of them being grown for local consumption. The production of sweet potatoes during the 1928-38 period increased from 240,000 bushels in 1929 to 720,000 bushels in 1932, and then declined to 240,000 bushels in 1939. The largest quantity, 720,000 bushels, was produced in 1932 (Fig. 17). The number of bushels shipped in carload lots averaged about 3.9 per cent of total production during the 1928-38 period and has not exceeded 12.9 per cent of production at any time since 1928. The per cent shipped in carload lots has declined materially since 1929, and since 1933 has averaged less than 1 per cent

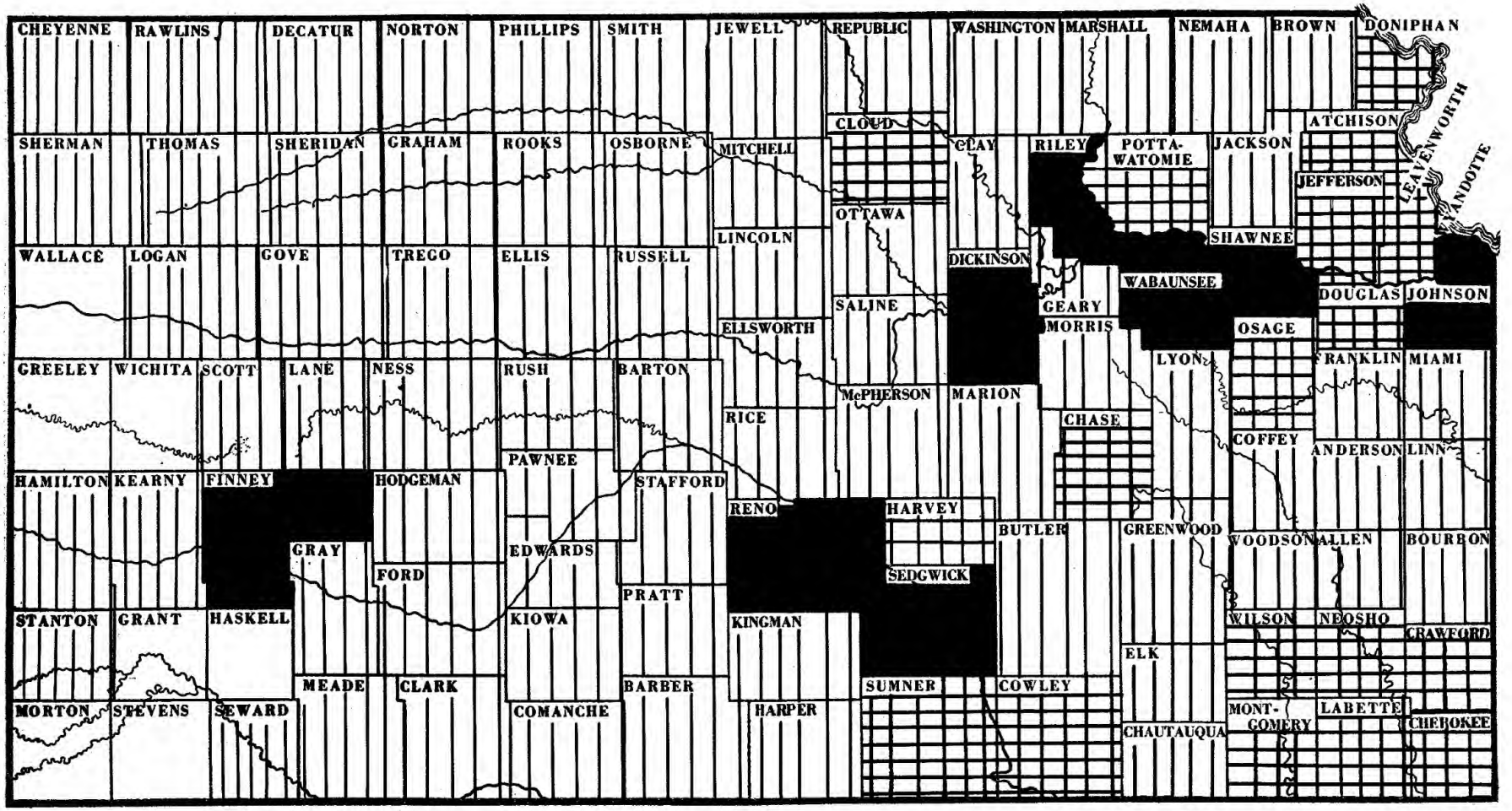


Fig. 16. Production of sweet potatoes by counties in Kansas. 1925-38 average (7).

Table 15. Kansas sweet potato acreage, production, and yield per acre by important producing counties in Kansas (7,14).

County	Acreage			Production (000 omitted)			Yield (bushels)		
	1925-38 average	1937	1938	1925-38 average	1937	1938	1925-38 average	1937	1938
Shawnee	427	320	340	52	22	46	119	70	135
Wyandotte	362	385	235	44	44	32	128	115	135
Dickinson	215	80	25	25	5	3	111	60	115
Johnson	207	282	310	19	18	42	137	65	135
Riley	150	140	214	19	17	31	126	120	145
Wabaunsee	122	165	156	11	12	16	96	70	105
Sedgwick	474	415	450	48	31	63	99	75	140
Reno	304	197	150	31	15	15	101	75	100
Finney	95	90	100	12	10	18	138	115	180
Kansas	4,000	3,000	3,000	400	240	375	104	80	125

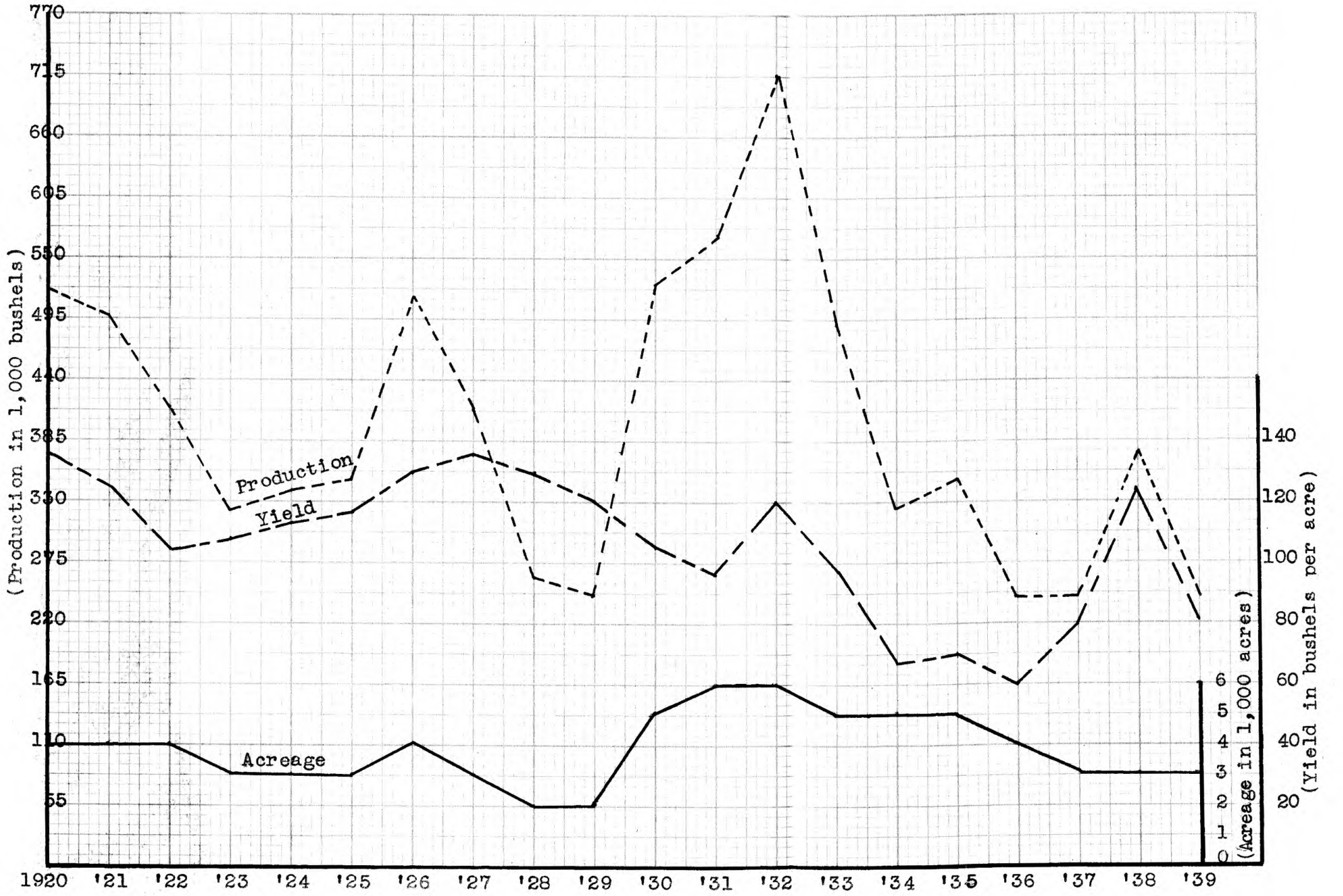


Fig. 17. Acreage, yield, and production of sweet potatoes in Kansas, 1920-39 (14).

of the total volume produced (Table 16). This decline in the number of sweet potatoes shipped by rail probably is caused by three factors: (1) A steady increase in the use of truck transportation during the last 10 years, (2) a decrease in the price farmers have received for sweet potatoes, and (3) an increase in the prevalence of sweet potato disease, a factor which has lowered the quality of Kansas sweet potatoes.

Sweet potatoes ranked seventh as a source of Kansas farm crop income from 1925 to 1934. They produced about $420,000 annual income, on the average, to Kansas farmers during this period (Table 5).

The sweet potato acreage in Kansas increased from an average annual acreage of 3,200 during the 1920-29 period to an average annual acreage of 4,500 for the 1930-39 period (Fig. 17). This is an increase in annual acreage of about 1,300 acres--41 per cent. In comparing the same periods, the yield per acre declined from an average of 122 bushels per acre in 1920-29 to an average yield of 90 bushels per acre during the 1930-39 period. This was a decrease in yield per acre of 32 bushels--26 per cent. The increase in acreage more than offset the decrease in yield per acre when comparing 1930-39 with the 1920-29 average production. The production for the 1930-39 period averaged 407,500 bushels a year and production for the 1920-29 period averaged 388,800 bushels. This was an increase of 18,700 bushels--about a 5-per cent increase in production from 1930-39 as compared with 1920-29.

Table 16. Production and carlot shipments of sweet potatoes and per cent produced that were shipped in carlots in Kansas, 1928-1938 (2,13).

Year	Production	Carlot shipments/10 (bushels)	Per cent of production shipped in carload lots
1928	260,000	31,500	12.1
1929	240,000	31,050	12.9
1930	525,000	33,300	6.3
1931	570,000	19,800	3.5
1932	720,000	36,000	5.0
1933	490,000	10,350	2.1
1934	325,000	0	0.0
1935	350,000	900	0.3
1936	240,000	0	0.0
1937	240,000	450	0.2
1938	375,000	2,700	0.7
Average of annual percentages			3.9

/10 Estimated 450 bushels per car.

Prices of sweet potatoes have been declining generally since 1925 (Fig. 18). In 1925 the average annual farm price per bushel for sweet potatoes in the United States was $1.65 and gradually declined to a low of 54 cents a bushel in 1932. Since 1932, the average annual farm price has improved and was 74.9 cents a bushel in 1939 (Fig. 18).

Sweet potato harvesting in Kansas is well underway in September or early October and local sweet potato prices, which usually are high at the beginning of the season, drop to a point considerably below terminal market prices. According to Elmer (17), this has resulted in the past, even in seasons of short crops. This glut in the local markets causes a sharp seasonal decline in prices Kansas farmers receive for their potatoes (Fig. 19). This same seasonal trend in sweet potato prices is shown by the prices farmers received for their product on the Kansas City curb market (Fig. 20).

Sweet potato prices usually improve during the winter months. Consequently, better prices may be obtained by those growers who have storage facilities. However, there are storage and shrinkage costs which must be deducted. From 1935 to 1939, the prices farmers received for their sweet potatoes in Kansas averaged $1.10 a bushel in September, 89 cents a bushel in October and in November (Table 17). The yield per acre in the principal producing area for the same period averaged about 94 bushels an acre.

Fig. 18. Prices received per bushel for sweet potatoes by farmers in Kansas and in the United States, 1922-39 (14).

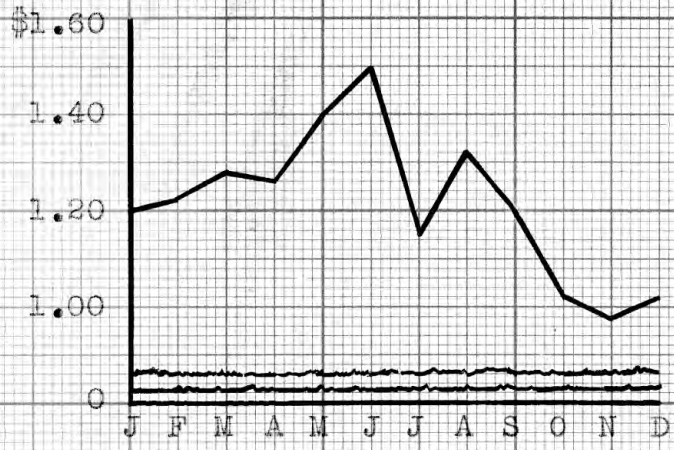


Fig. 19. Estimated price of sweet potatoes received by producers in Kansas. Average monthly price per bushel, based on 1926-39 average (14).

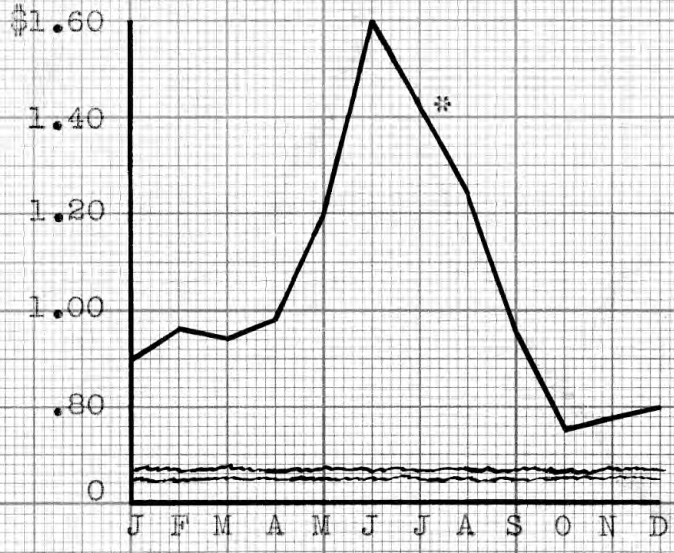


Fig. 20. Prices received per bushel by growers on Kansas City curb market. Average monthly prices based on 1931-1938 average (28).

* Not enough quotations in July for an average.

Table 17. Estimated price per bushel received by Kansas producers for sweet potatoes during September, October, and November, 1926-39 (14).

Year	Month		
	September	October	November
1926	$1.50	$1.40	$1.25
1927	1.40	1.15	1.10
1928	1.05	1.10	1.10
1929	1.55	1.45	1.45
1930	1.45	1.15	1.10
1931	.95	.90	.85
1932	.60	.55	.45
1933	1.40	.95	.75
1934	1.40	12 5	1.10
1935	1.15	.70	.85
1936	1.55	1.35	1.25
1937	1.10	.90	.85
1938	.85	.70	.70
1939	.85	.80	.80
1935-39 average	1.10	.89	.89
1926-39 average	1.20	1.02	.97

The United States Department of Agriculture estimated that approximately 20 per cent of the sweet potatoes are culls.

At the present time most of the Kansas sweet potatoes are consumed locally. No data could be obtained as to the quantity of sweet potatoes transported out of Kansas by truck, so the actual quantity of potatoes marketed outside the state probably is larger than indicated by the carlot shipments of sweet potatoes. However, the sweet potato industry, as it exists today, probably can be described best as an industry limited to producing a commodity mainly for local consumption.

SWEET POTATO STARCH FACTORIES IN THE UNITED STATES

The only data that could be obtained about sweet potato factories pertained to the plant at Laurel, Mississippi. Correspondence with C. T. Dowell, Director of the Louisiana Experiment Station, indicated that a sweet potato starch factory is being built at St. Francisville, Louisiana, at the present time. However, the plant at Laurel is the only one in the United States which has operated any length of time or from which any data could be obtained.

The Laurel starch factory was established in 1934 under the supervision of the Bureau of Chemistry and Soils, now renamed the Bureau of Agricultural Chemistry and Engineering. One purpose of the plant was for experimental work in developing a new industry

that could supplement the cotton crop for the South. A great deal of experimental work has been done in developing manufacturing technique and in improving starch-producing varieties of sweet potatoes and methods of their production.

The Federal Emergency Relief Administration financed the plant in its early stages of development, and the sweet potato growers also received per-bushel crop-diversion payments from the Agricultural Adjustment Administration. At the present time the plant is owned and operated by a cooperative organization of about 1,200 farmers called the Sweet Potato Growers, Incorporated. The organization is not entirely "on its own feet". Technical supervision and assistance are furnished by the Bureau of Agricultural Chemistry and Engineering. However, the output of the plant has grown from a production of 140,000 pounds of starch in 1934 to an expected output of 3,000,000 pounds in 1939. A great deal of work in improving the efficiency of the manufacturing process resulted in a decrease in the cost of making starch from 13 cents a pound in 1934 to slightly less than three cents a pound in 1936. These costs include the cost of raw material at a price of about 20 cents a bushel.

Research workers at the Laurel plant estimate the cost of manufacturing starch, exclusive of raw materials, to be about one cent a pound. The capacity of the Laurel plant is now 15 to 17 tons of starch a day. With a factory three times the size of the Laurel factory, they estimate a starch processing cost of about 0.75 cents a pound.

The sales of the plant have been within the range of four to 4½ cents a pound for starch, f.o.b., Laurel, Mississippi. At such prices and with total costs averaging about three cents a pound, a fair profit is realized.

In Mississippi it has been possible to attain a yield of about 300 bushels per acre of sweet potatoes grown for starch purposes (Table 18). Thus, with a price of 20 cents a bushel for sweet potatoes, the farmer can gross about $60 an acre. The profit to the farmer, of course, depends largely upon the yield and starch content of the potatoes.

Table 18. Average yield and starch content of sweet potatoes (35).

Variety	Yield (Bu.)	Per cent starch content
Mississippi Blue Stem Triumph	308	24
Wennop (from Australia)	303	27
Preison	293	26
U. S. 95984	279	21
Mississippi Green Stem Triumph	275	25
U. S. 85985	275	21
Norton	267	28
Nancy Hall	252	22
Porto Rico	244	21
Southern Queen	212	23

With a yield of 300 bushels of sweet potatoes an acre with an average starch content of 23.8 per cent, some of the Mississippi farmers have been able to produce about two tons of starch an acre. Thus, it would require about 750 acres of sweet potatoes, yielding 300 bushels an acre with an average starch content of 23.8 per cent, to furnish the raw material for a 15-ton starch factory for 100 days.

A 15-ton factory is considered by the Laurel office to be the minimum size plant for sweet potato starch production. Overhead costs per unit become too large an item in smaller plants, and for this reason a factory larger than 15 tons may be desirable. So far, the Laurel plant has been able to operate only about 100 days a season due to the fact that no completely satisfactory method of sweet potato storage has been devised. Experimental work is being carried on at the Laurel plant in an attempt to develop a dehydrating process for sweet potatoes which would allow sweet potatoes to be stored economically for considerable lengths of time. It is hoped the dehydrated pulp can be supplied to the starch factory through the entire year; this would materially decrease overhead costs per unit.

As far as could be determined, the process of manufacturing sweet potato starch closely parallels the manufacture of Irish potato starch. Much of the equipment in the Laurel plant is Irish potato starch manufacturing equipment imported from

Germany. Probably the largest difference in the process is the use of chemicals during the sieving process to remove the pigment which discolors sweet potato starch. Another difference is that the plant at Laurel uses a hammer mill to disintegrate the potatoes instead of the rotating rasp grinder. According to correspondence with both H. S. Paine and J. A. Ambler of the Carbohydrate Research Division of the Bureau of Agricultural Chemistry and Engineering, United States Department of Agriculture, a plant such as that at Laurel, Mississippi, could be used for the manufacture of Irish potato starch but sweet potato starch could not be satisfactorily processed in Irish potato starch factories as constructed in Maine.

It was not possible to obtain capitalization costs of a sweet potato factory. The factory at Laurel has been operated to a large extent on an experimental basis; therefore, the costs for establishing a new factory in which proven equipment could be installed should be considerably less. Probably the cost of building a sweet potato starch factory would be comparable to that of a modern Irish potato starch plant, which is about $75,000 for a factory with a capacity of 10 tons a day.

Production of sweet potatoes for table use and production for starch production are entirely different enterprises, although cull sweet potatoes which are not edible could be used for starch production.

The experiments carried on in connection with the Laurel plant have been for the purpose of developing a sweet potato high in starch content which also gives a high yield per acre. Edible properties of the sweet potato are considered of little importance. It was found that larger yields can be obtained by spacing the plants further apart at planting time than has been the ordinary practice and allowing the roots to grow until they reach a large size. Sweet potatoes are roots and continue to grow until dug or killed by frost or some other factor. They will continue to grow and may attain a size several times larger than those commonly found on markets.

The production of sweet potatoes for starch production costs less than the production of sweet potatoes for the truck-crop market. Fewer plants are required per acre and less labor needs to be used in preparing them for market. Also, a combination digger and loader is being developed at Laurel which will greatly lower the costs of harvesting. This machine probably will not soon become practical in the harvesting of sweet potatoes for table use because of the bruising effect on the potatoes. Thus, it is entirely possible that growers producing sweet potatoes for a starch factory can net a larger return from an acre of sweet potatoes than those growers producing for the retail market even though their gross returns are smaller.

The sweet potato starch industry also yields some by-products. If the vines were properly cut and harvested, the

growers at Laurel have been able to obtain from 0.5 to 2.0 tons of hay an acre, which is about equal in feeding value to red and crimson clover hay (Table 19).

The factory has been able to sell dehydrated pulp, from which the starch has been removed, to dairymen for $27 a ton. However, the cost of dehydration was not given in any reports of the work.

Table 19. Sweet potato vine hay as compared with leguminous hay (35).

	Sweet potato vine hay	Ave. of red clover, crimson clover, cowpeas and soybean hay
	(Per cent)	(Per cent)
Protein	12.5	16.8
Fat	4.9	3.8
Fiber	18.2	26.8

As was indicated, the Laurel plant has been conducted mainly on an experimental basis. Therefore, some of the results are based on facts and others are based on experiments now underway. Nevertheless, they give some insight into the costs of sweet potato starch manufacture. Undoubtedly, further experiments being carried on there will result in lowered costs of manufacture and increased financial returns to the sweet potato grower.

THE ECONOMIC ASPECTS OF THE SWEET POTATO STARCH INDUSTRY IN KANSAS

If a sweet potato starch factory were to be established in Kansas, it probably should be a complete unit capable of producing a finished product of at least 15 tons of starch a day. The overhead costs per unit with a smaller plant probably would be excessive.

A 15-ton sweet potato starch factory should operate at least 100 days during the year to reduce fixed costs per unit of output. Such a factory would need a minimum annual supply of at least 300,000 bushels of sweet potatoes. This quantity is about equal to the total annual production of Kansas sweet potatoes and is less than is produced in some years. If the portion of the crop sold commercially were diverted to a 15-ton starch factory, it would supply the factory less than 10 days. Even though the supply of sweet potatoes in Kansas were large enough to operate a starch factory 100 days, the growers probably would not be willing to sell all their sweet potatoes to a starch factory for 20 to 30 cents a bushel, which is all a factory could afford to pay for sweet potatoes for starch manufacture. Since 1926, growers have never received a price of less than 45 cents a bushel. In view of this situation and with present limited sweet potato production, it appears that a sweet potato starch factory would not be economically advisable in Kansas.

However, if yields can be obtained in Kansas comparable to the yields that have been obtained from sweet potatoes grown for starch production purposes in Mississippi, the establishment of a factory might be advisable.

The plant at Laurel, Mississippi, has been receiving about four to 4½ cents a pound for the starch, f.o.b. factory. If a starch factory which would turn out a product of equal quality were established in Kansas, approximately the same price probably would be received for the starch.

About 10 pounds of starch can be obtained from a bushel of sweet potatoes. Thus, with a cost of production, exclusive of raw material, of about one cent per pound of starch produced, a sweet potato starch factory could pay a maximum price of about 20 to 30 cents a bushel for the raw material.

If sweet potatoes yielding 300 bushels an acre, on the average, and having 23.8 per cent starch content could be produced in Kansas, it would gross the grower at least $60 an acre at starch-factory prices of 20 cents a bushel. Whether or not these yields could be consistently obtained in Kansas or whether growers would be willing to grow sweet potatoes at these returns has not been determined. However, before a sweet potato starch factory is established in Kansas, these two major factors should be considered.

CORN PRODUCTION IN KANSAS

The annual cash income received by Kansas farmers from corn amounted to an average of about $15,533,000 from 1925 to 1934. During this period corn ranked second to wheat in importance as a source of cash farm income and returned about 12 per cent of the total average income obtained from important Kansas crops (Table 5).

Acreage harvested, yield, and production of corn has declined in Kansas during the past 10 years. This is due, to a large extent, to the below normal rainfall during the last several years. From 1920 to 1929 the annual acreage of corn harvested averaged about 5,931,000 acres. From 1930 to 1939 the annual acreage harvested declined to about 4,609,000 acres. This was a decline of 1,322,000 acres--about 22 per cent. The yield for the same periods declined from an average of 21 bushels an acre to an average of 12 bushels an acre--about 43 per cent. From 1920 to 1929, the production declined from an average of 125,451,000 bushels to an average of 59,550,000 bushels for the 1930-1939 period. This was a decline in production of about 65,901,000 bushels annually, about 53 per cent (Table 20).

The prices farmers received for corn show that there is a definite but not widely fluctuating seasonal price for corn (Fig. 21). Corn prices in Kansas usually reach a peak in August.

Table 20. Acreage, yield, and production of corn in Kansas, 1920-39 (7,14).

Year	Kansas		
	Acreage harvested (000 omitted)	Yield (bushels)	Production (000 omitted)
1920	5,331	26.2	139,672
21	4,638	22.8	105,746
22	5,195	19.0	98,705
23	5,713	23.0	131,399
24	6,056	21.7	131,415
25	6,722	17.6	118,307
26	5,781	11.5	66,482
27	6,241	27.0	168,507
28	6,988	25.0	174,700
29	6,643	18.0	119,574
1930	6,776	12.0	81,312
31	6,573	18.0	118,314
32	7,362	19.0	139,878
33	6,994	11.5	80,431
34	3,777	3.5	13,220
35	4,380	9.0	39,420
36	2,759	4.0	11,036
37	2,456	12.0	29,472
38	2,260	20.0	45,200
39	2,757	13.5	37,220
1920-29 ave.	5,931	21.2	125,451
1930-39 ave.	4,609	12.2	59,550

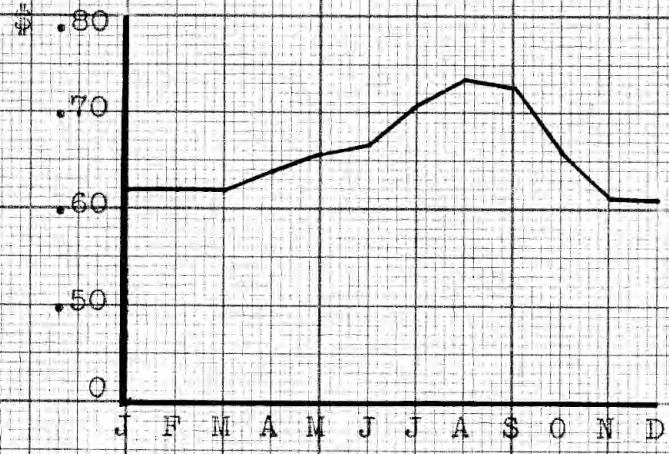


Fig. 21. Estimated average monthly price per bushel of corn received by farmers in Kansas, 1926-39 (14).

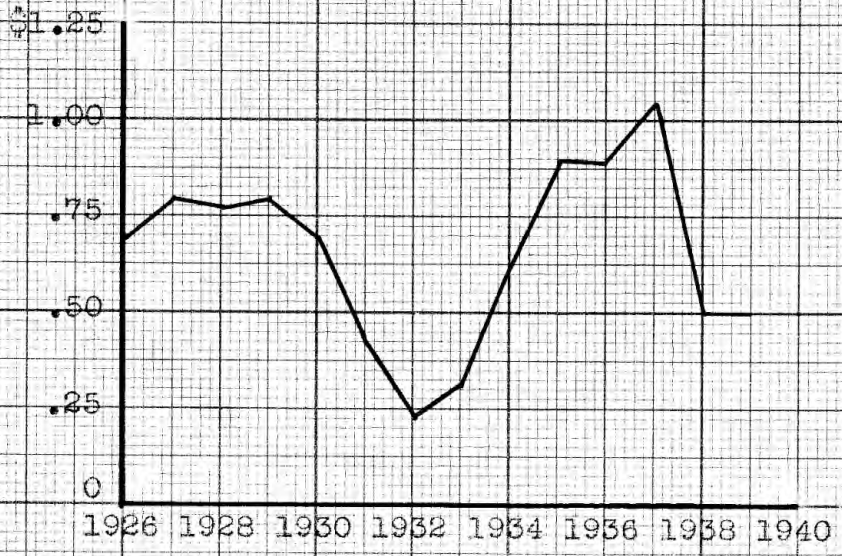


Fig. 22. Estimated average annual price per bushel of corn received by farmers in Kansas, 1926-39 (14).

Prices then decline fairly rapidly until November when they tend to level off through the winter months. By March, prices usually improve seasonally and, in most years, this trend continues until August.

In the 14-year period from 1926 to 1939 there were six years when the average annual price received by farmers was more than 75 cents a bushel and only three years when the price was below 50 cents a bushel. In 1937 the average annual price received by farmers was $1.06 a bushel and in 1932 it was 24 cents a bushel (Fig. 22).

Total production of corn in Kansas is extremely variable (Fig. 23), ranging from a high of more than 170 million bushels in 1928 to a low of less than 15 million bushels in 1934 and 1936 (Table 20).

While corn is produced in every county in Kansas, the most important corn-producing area is made up of counties in the northeastern part of the state and of one tier of counties extending along the northern border of the state (Fig. 24).

During the ten-year period 1927-36 Kansas was eighth in the United States in importance as a corn-producing state. In 1937, 1938, and 1939, Kansas ranked 21st, 18th, and 16th, respectively (Table 21).

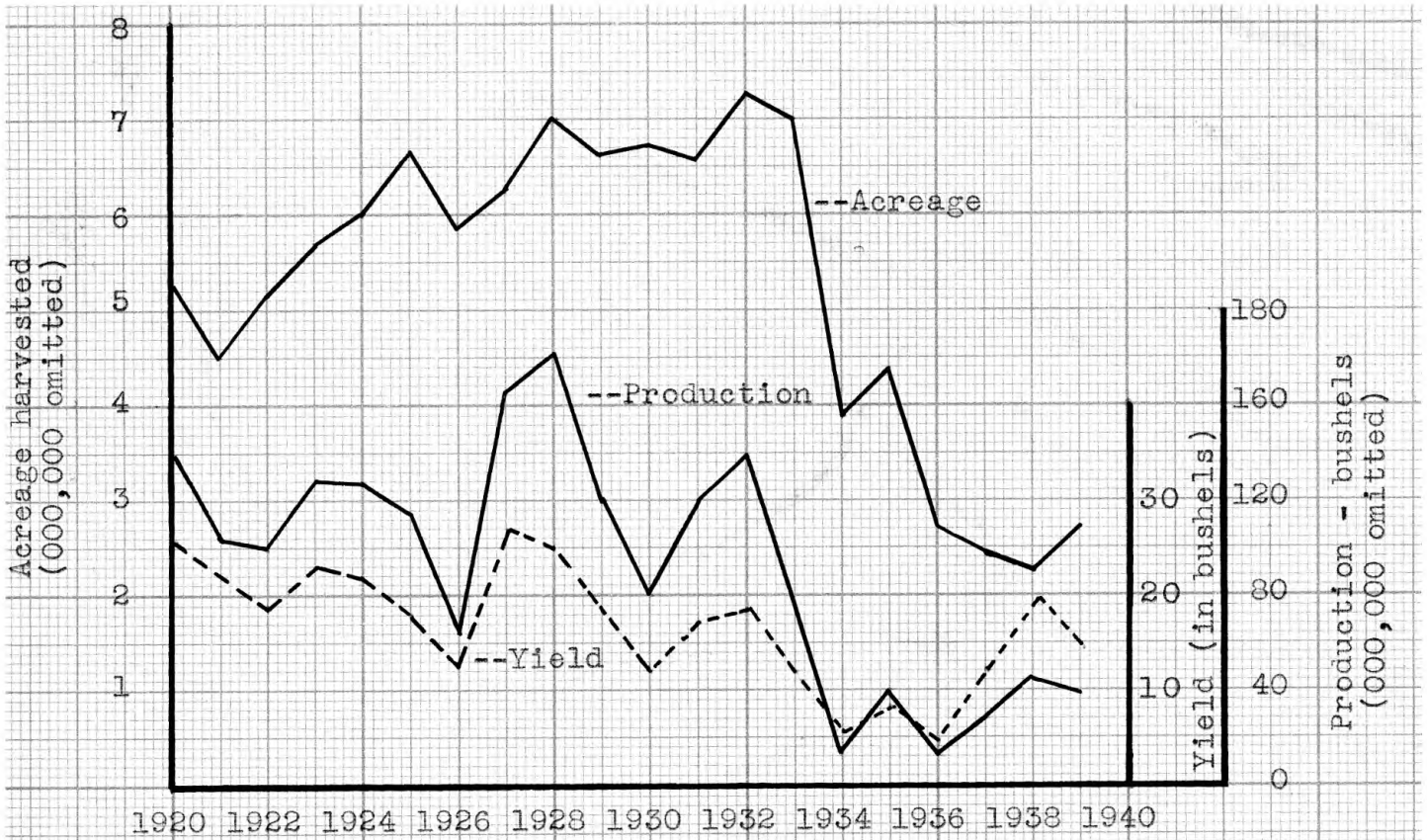
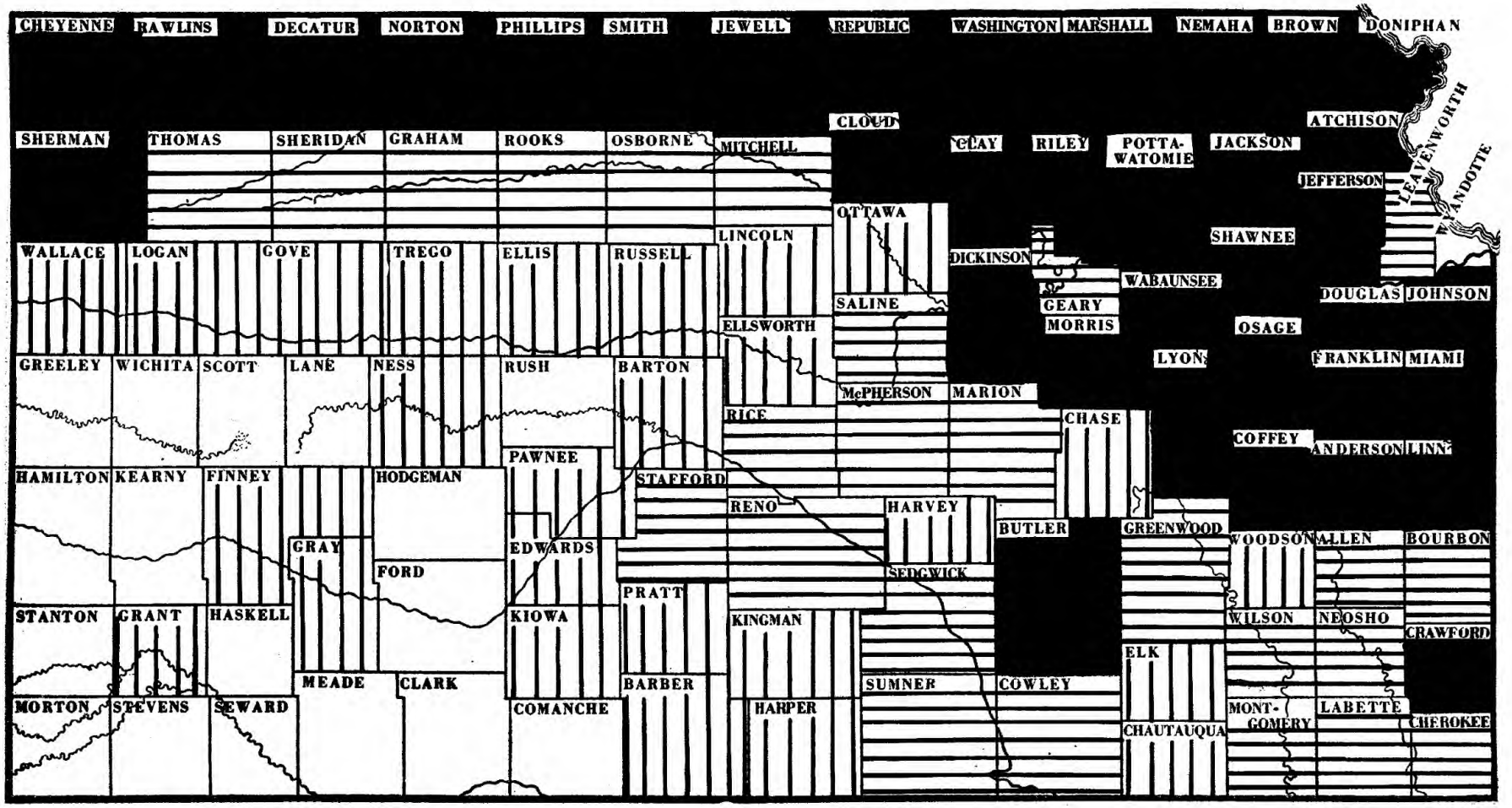


Fig. 23. Acreage, yield, and production of corn in Kansas, 1920-1939 (7).



Less than 200,000 bushels

200,000 to 500,000 bushels

500,000 to 1,000,000 bushels

More than 1,000,000 bushels

Fig. 24. Average annual production of corn in Kansas, 1925-38 (8).

Table 21. Production and rank of important corn-producing states, 1927-38 (2,14).

State	Average 1927-36		1937		1938		1939	
	Total production	Rank	Total production	Rank	Total production	Rank	Total production	Rank
	(1,000 bu.)		(1,000 bu.)		(1,000 bu.)		(1,000 bu.)	
Iowa	381,704	1	498,690	1	468,923	1	503,776	1
Illinois	289,731	2	449,616	2	379,350	2	418,652	2
Nebraska	180,280	3	82,992	7	107,735	6	82,032	8
Indiana	143,334	4	213,840	3	173,389	3	213,416	3
Minnesota	131,370	5	172,368	4	157,535	4	204,796	4
Ohio	127,177	6	163,228	5	156,992	5	171,250	5
Kansas	94,639	7	29,472	21	45,200	18	37,220	16

THE ECONOMIC ASPECTS OF CORN STARCH MANUFACTURE IN KANSAS

According to the 1938 "Statistical Abstract of the United States", there are 36 factories in the United States processing corn syrups, corn sugar, corn oil, and corn starch. Most of these factories are located farther east than Kansas. Kansas is on the edge of the Corn Belt and only those counties along the northern and eastern sides of the state produce corn in large quantities (Fig. 24). Because of this, starch manufacturers would be reluctant to establish factories in most parts of Kansas. By establishing factories farther east in the leading states of the Corn Belt, they are assured of not only a larger supply but also a more uniform supply over a period of years.

However, there is a corn products factory in operation at Kansas City, Missouri. This plant is not selling corn starch but is extracting a wet starch from the corn and further processing this starch into corn syrup and sugar. Salad oil and stock feeds also are produced.

The plant has the capacity to process about 17,000 bushels of corn a day. It represents an investment of about $1,000,000 and employs regularly about 30 to 40 men.

Since there is a corn products factory already established in Kansas City, Missouri, and in view of the variable and

relatively small production in most of Kansas, it may be concluded that the establishment of additional factories for corn starch manufacture in this state would not be feasible.

It is interesting to note that in the 1880's there was a corn processing factory at Topeka. The factory was established in 1882 with a capacity of about 200 bushels of corn a day and employed about 12 men. However, it was impossible to determine when the operation of the factory was discontinued or the causes for its being closed.

GRAIN SORGHUM PRODUCTION IN KANSAS

During the ten-year period 1925-34, grain sorghum ranked fourth as a source of cash crop income to Kansas farmers. The average annual income to Kansas farmers from grain sorghums during this period was about $1,590,000 (Table 5).

Since 1930 the acreage has been slightly more than during the period from 1920 to 1929 (Fig. 25). However, the yield per acre and the total production have both declined materially since 1930. In the 10-year period from 1920 to 1929 the yield averaged about 16.4 bushels an acre, while from 1930 to 1939 the average yield was only about 9.2 bushels an acre. This was a decline of 7.2 bushels an acre in average yield--about 44 per cent. The reduction in production for the same two periods was from an average of 20,489,000 bushels in the 1920-29 period to

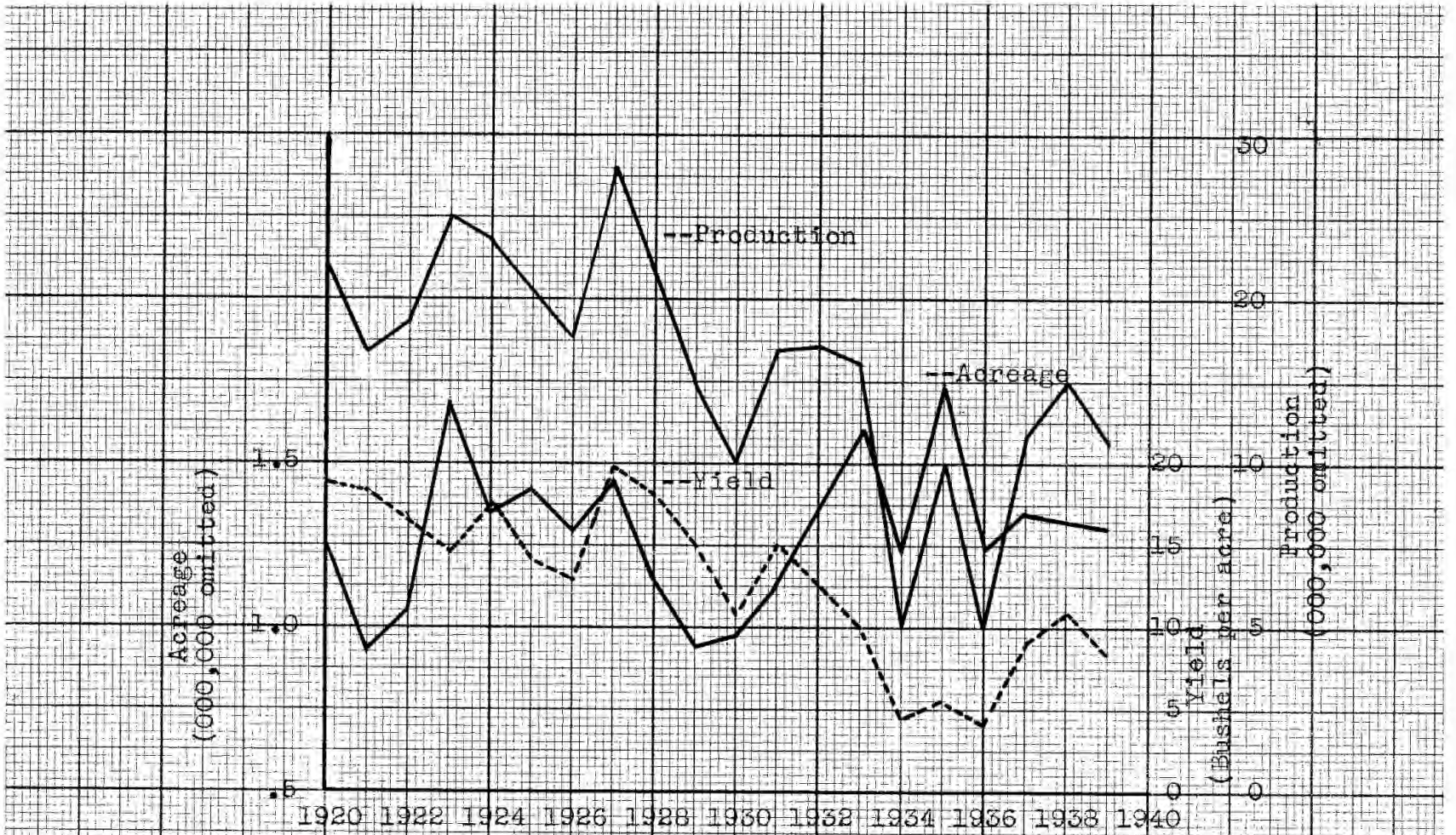


Fig. 25. Acreage, yield, and production of grain sorghum in Kansas, 1920-1939 (7).

11,968,000 bushels during the 1930-39 period. This was a reduction of 8,521,000 bushels, a decline in production of about 42 per cent (Table 22).

The most important area is shown by the county production data for 1935, 1937, and 1938, and lies in the southeastern part of the state (Fig. 26). (Total production of grain sorghums by counties was not included in the Biennial Reports of the State Board of Agriculture prior to 1935, and in 1936 there was such a small quantity of grain sorghum harvested for grain that no report was included for that year).

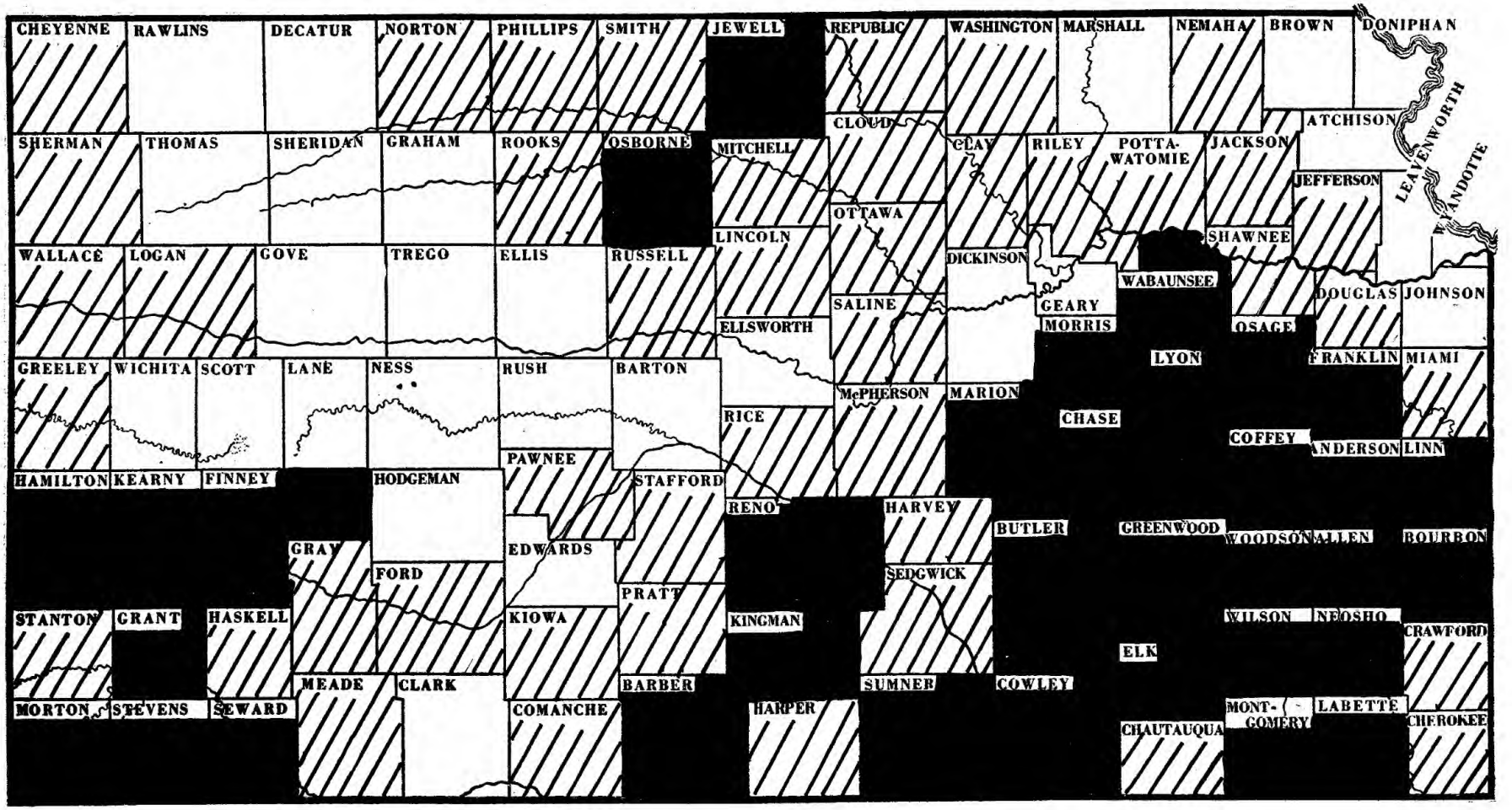
There also are seven counties in the southwestern corner of the state that produced an average of more than 100,000 bushels of grain sorghums annually during the period from 1935 to 1938, inclusive. Jewell and Osborne counties in north central Kansas also averaged more than 100,000 bushels each in annual production for this three-year period.

There were 34 counties in Kansas that produced, on the average, more than 100,000 bushels of grain sorghum each in 1935, 1937, and 1938 as compared with 66 counties that produced more than 100,000 bushels of corn for this same period. This indicates the relative importance of corn and grain sorghums in Kansas in recent years.

From 1934 to 1939 the average annual price received for grain sorghum by producers in Kansas has averaged about 75 cents a

Table 22. Grain sorghum acreage, yield, and production in Kansas, 1920-1939 (7,14).

Year	Acreage (000 omitted)	Yield (bu. per acre)	Production (000 omitted)
1920	1,258	18.5	23,273
21	907	18.0	16,326
22	1,061	16.5	17,506
23	1,698	14.5	24,621
24	1,324	17.5	23,170
25	1,430	14.0	20,020
26	1,287	13.0	16,371
27	1,441	19.5	28,100
28	1,153	18.0	20,754
29	959	15.0	14,385
1930	988	10.5	10,374
31	1,107	15.5	17,158
32	1,328	13.0	17,264
33	1,607	10.0	16,070
34	1,195	4.5	5,378
35	1,760	5.5	9,680
36	1,214	4.5	5,463
37	1,370	9.0	12,330
38	1,343	11.0	14,773
39	1,316	8.5	11,186
Average 1920-29	1,252	16.4	20,489
Average 1930-39	1,323	9.2	11,968



Less than 50,000 bushels 50,000 to 100,000 bushels More than 100,000 bushels

Fig, 26. Production of grain sorghums in Kansas, average of 1935, 1937, and 1939 (7).

bushel, ranging from a low of 44 cents in 1938 to a high of $1.04 in 1935 (Figs. 27 and 28).

During the period from 1934 to 1939 the average annual price of grain sorghum was about the same as the price of corn.

THE ECONOMIC ASPECTS OF SORGHUM STARCH PRODUCTION

As nearly as could be determined, it appears that there are no sorghum starch factories in operation in the United States. Mr. F. Holm, Manager, Corn Products Refining Company, Kansas City, Missouri, said that at one time an attempt had been made in that plant to produce grain sorghum starch with corn starch equipment. While it was possible to produce starch from grain sorghum, many complications developed from the fact that corn starch manufacturing equipment is not entirely satisfactory for processing grain sorghum because of the difficulty involved in removing the germ from the sorghum kernel; as a result, the use of grain sorghums was soon discontinued.

Because of variable climatic conditions in Kansas, grain sorghums are one of the more certain crops from year to year. In view of this fact and because of the large potential production in this area, grain sorghums may prove to be the best farm product to be utilized for starch production purposes in Kansas. Starch production technique for grain sorghum is now in the experimental stages and until more is known about it, making an estimate of the economic advisability of such a factory in Kansas is impossible.

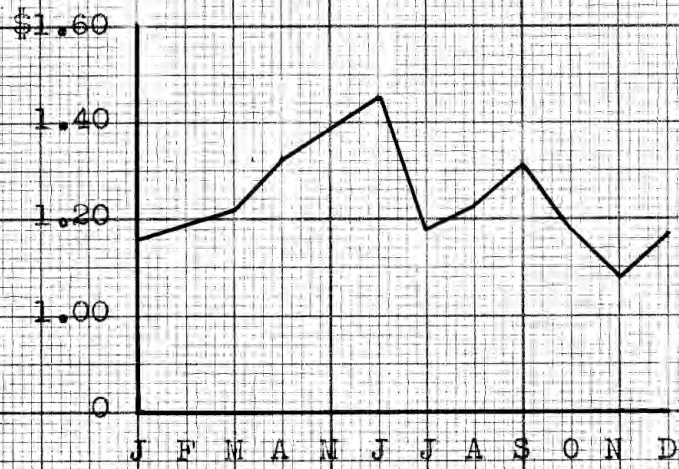


Fig. 27. Estimated average monthly price per hundred pounds received for grain sorghums by farmers in Kansas, 1934-1939 (14).

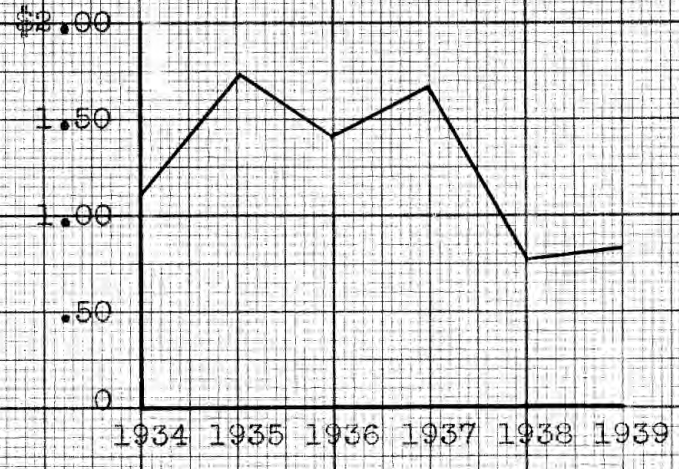


Fig. 28. Estimated average annual price per hundred pounds received for grain sorghums by farmers in Kansas, 1934-1939 (14).

SUMMARY AND CONCLUSIONS

At the present time root starches are being imported into the United States and cereal starches are being exported. Apparently there is an opportunity for Irish and sweet potato starch manufacturers to make a considerable quantity of starch in the United States, provided they can meet foreign competition.

Corn starch manufacturers, however, probably will have to export larger quantities of starch or develop new uses for corn starch before the market for this product can be expanded to any large extent.

An analysis of the data and information from various sources indicated the following facts concerning Irish potato starch factories.

(1) A factory capable of producing 10 tons of starch a day is considered to be the minimum economic unit for a modern potato starch factory.

(2) The fixed capital and equipment cost for a modern potato starch factory averages approximately $75,000.

(3) On the average, it requires 10 pounds of low-grade potatoes to produce one pound of starch.

(4) Manufacturing costs exclusive of raw materials are approximately 1½ cents a pound, f.o.b. factory basis.

(5) The factory should operate at least 100 days a year to reduce overhead costs per unit to an economical basis. This indicates that a potential volume of about 350,000 bushels of potatoes should be available annually.

(6) The average, modern potato starch factory requires from 10 to 12 workers, of whom only one or two need to have any high degree of technical skill or managerial ability.

(7) Prices paid for potatoes for starch manufacture range from 10 to 35 cents a hundred pounds in most years, based on the yield of starch and the price that can be obtained for it.

The study of Irish potato starch production was limited to the Kaw Valley, as it is the most important commercial producing area in Kansas; and if an Irish potato starch factory were feasible in Kansas, the Kaw Valley is the most likely location.

In analyzing the requirements of an Irish potato starch factory in relation to the potato industry as it exists in the Kaw Valley, it appears reasonably certain that an Irish potato starch factory could not be operated profitably in view of the following factors.

(1) Potatoes grading U. S. No. 2 or above are too valuable as human food in most years to be used in starch manufacture.

(2) With present acreage and production, the supply of cull potatoes is not large enough to provide an adequate supply of raw material to operate a 10-ton starch factory 100 days a year; and,

as far as could be determined, there are no alternative uses for potato starch factories.

(3) Most of the potatoes produced in the Kaw Valley are harvested in July. Because of the extremely hot weather during the harvesting season, it would be practically impossible to keep potatoes in common storage for any length of time, and the costs of keeping potatoes in cold storage for starch purposes are prohibitive. Thus, even though the supply of raw materials were not a limiting factor, the problem of storage probably would make the project inadvisable.

(4) If the factories were to operate during the harvesting season, the hot weather would cause fermentation of the starch milk and complicate the manufacturing process.

An analysis of the data and information from the various sources indicated the following facts concerning sweet potato starch factories.

(1) A factory capable of producing 15 tons of starch a day is considered to be the minimum economic unit for a modern sweet potato starch factory.

(2) The fixed capital and equipment cost for a modern sweet potato starch factory probably is quite comparable to that for an Irish potato starch factory of the same capacity.

(3) On the average, one bushel of sweet potatoes, produced for starch production, yields about 10 pounds of starch.

(4) Manufacturing costs exclusive of raw material are approximately 0.75 to 1.0 cent a pound for a factory with a capacity of 15 tons of starch a day.

(5) The factory should operate at least 100 days a year to reduce overhead costs per unit to an economical basis. Such a factory would need an annual supply of at least 300,000 bushels of sweet potatoes yielding 20 per cent starch.

(6) Mississippi growers have been obtaining about 20 cents a bushel for sweet potatoes sold to the Laurel starch factory.

The total average annual production of sweet potatoes in Kansas during the last few years has not been sufficient to operate economically a sweet potato starch factory. If other factors are considered, such as scattered production, variable annual production, and prices received for the high-grade portion of the crop, it becomes evident that under present conditions a sweet potato starch factory could not operate successfully in Kansas. However, if yields of at least 300 bushels of sweet potatoes an acre could be obtained consistently in Kansas and these potatoes should average at least 20 per cent starch content, it is entirely possible that a profitable sweet potato starch industry might be developed in Kansas.

In view of the following factors it does not appear that it would be economically advisable to establish a corn starch factory in Kansas.

(1) There is a corn starch products refining company at Kansas City, Missouri, and the development of another factory in Kansas probably would not be practical.

(2) Due to the variability of production of corn, especially in the western half and the southern part of Kansas, the supply of corn for manufacture of starch at any point west of Kansas City probably would be too variable from year to year to warrant the establishment of a corn starch factory.

The data available are not sufficient to determine the economic feasibility of a grain sorghum starch factory in Kansas. However, because of the fact that grain sorghums are an important crop in Kansas and that fairly uniform production is obtained from year to year, further study in the fields of chemistry and economics may prove grain sorghums to be a good potential supply of raw material for starch production.

ACKNOWLEDGMENTS

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