BULLETIN NO. 259 MOSCOW, MARCH 1945

Potato Starch Production In Idaho

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Idaho's production of 30,000,000 bushels of potatoes annually results in 5,000,000 to 6,000,000 bushels of non-commercial grade. The starch plants in Idaho have a capacity of about 20,000,000 pounds of starch annually, which provides an outlet for around 3,000,000 bushels of cull potatoes—about one-half of the non-commercial grade—with a cash value to the farmer of $500,000.

Published by the University of Idaho, Moscow, Idaho

Potato Starch Production In Idaho*

HOBART BERESFORD AND MARVIN J. ASLETT†

CULL potato disposal presents one of the most important economic problems facing the Idaho potato industry. Prior to the demand for dehydrated potatoes and the development of the potato starch industry in Idaho, between 4 and 6 million bushels of the total of 30 million bushels of potatoes produced in Idaho annually were culls, and of little or no commercial value to the producer.

Potato starch production has brought over $2,000,000 in gross receipts to Idaho since its establishment three years ago. The three factories have processed over 350,000,000 pounds of potatoes in three operating seasons with the following production of starch:[1]

	1941-42 season Tons	1942-43 season Tons	1943-44 season Tons
St. Anthony plant	....	1,190	2,280
Blackfoot plant	1,500	2,550	4,400
Twin Falls plant	900	2,100	3,500
	2,400	5,840	10,180

The production of potato starch is an old industry. As early as 1765, the production of potato starch was being carried on in Germany.[2] The first starch factory in the United States was operated at Antrim, New Hampshire in 1831[3] and the industry grew until in 1860 there were about 152 factories in this country.[4] In 1900 there were 63 factories, in 1940 there were only 29, and many of these did not operate every season.[3] Twenty-seven of the twenty-nine plants were located in Aroostook County, Maine, and in 1940 had an annual capacity of 25,000,000 pounds of starch.

Development of White Potato Starch Industry in Idaho

Contacts were made with the potato starch industry in Maine relative to the problems of raw material supply, manufacturing, and marketing. A detailed report was obtained from the National Farm Chemurgic Council, and several personal trips were made throughout the country to get first hand information. The result of this prelim-

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*"Potato Starch Production in Idaho" is based on the data presented in "Flash Drying of Potato Starch," Marvin Aslett, Thesis, Professional Degree, Department of Agricultural Engineering, University of Idaho, 1943.

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[1]A fourth plant has been established at Menan, Idaho, 1944. Wet starch from Menan is processed by the St. Anthony plant, not in operation for 1943-44 season.

[2]Walton, Robert P. COMPREHENSIVE SURVEY OF STARCH CHEMISTRY, p. 139.

[3]Brautlecht, C. A. MANUFACTURE OF WHITE POTATO STARCH IN THE UNITED STATES, Industrial and Engineering Chemistry, Vol. 32, No. 7, p. 894.

[4]U. S. CENSUS, 1860.

inary work showed a very promising possibility of using the wasted cull potatoes in Idaho for manufacture of potato starch.

In order to determine the location of an adequate cull potato supply a study was made of the distribution of carlot loadings of potatoes for 1939-1940.[1] Figure 1 shows the distribution of the potato shipments with the area of each circle indicating an 18-mile radius, using the town location as center.

On the basis of this information it was decided that starch plants of 10-ton capacity would be feasible at Twin Falls and Blackfoot, and that a 5-ton unit could be located at St. Anthony. Work was begun immediately on organizing two private corporations consisting of local stockholders at Twin Falls and Blackfoot. The two plants of 10-ton capacity were built with identical flow sheets and equipment, the only difference being in the arrangement of the machinery and buildings (Figure 2). When each plant was completed, it represented roughly $62,000 in capital investment. Both plants were in operation by November 1, 1941.

[1]Public Utilities Commission of Idaho, COMPARATIVE CAR LOADING REPORT, 1940.

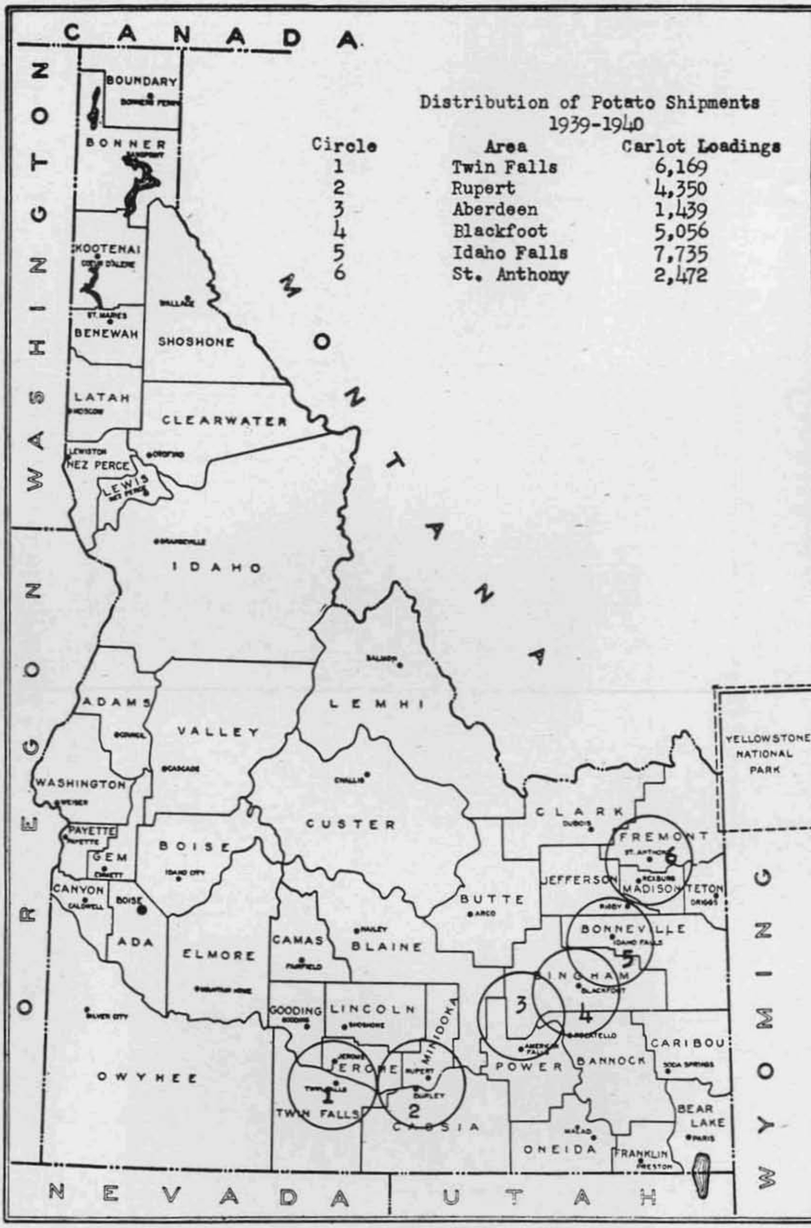


Figure 1.—Distribution of potato shipments.

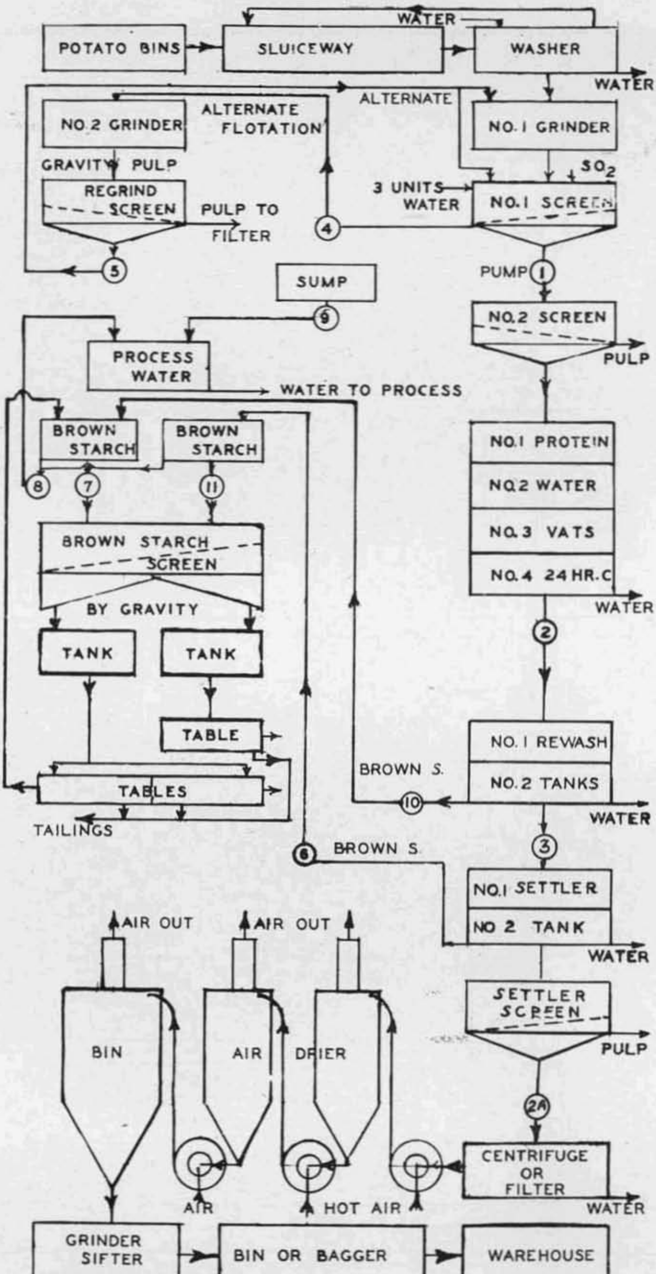


Figure 2.—White potato starch production flow sheet.

The 5-ton capacity plant at St. Anthony was constructed with the same type of organization. This corporation was granted a state charter May 4, 1942, and the plant was ready for operation September 20 of the same year. Approximately $35,000 was required to complete the plant.

In 1944, a fourth starch plant was established at Menan, Idaho, a few miles south of St. Anthony. This plant produces wet starch, which is delivered under contract to the St. Anthony plant for further processing, drying, and marketing. It was necessary for the St. Anthony plant to increase to a 15-ton capacity in order to handle the increased wet starch.

Preparation of Wet Starch

The Idaho potato starch factories use the bath-type system of preparing the wet starch. The cull potatoes are weighed and dumped into hopper bottom bins, which discharge into a concrete trough located at the bottom. Plank covers are removed permitting the potatoes to drop into a stream of water which carries them to the plant for washing. The potatoes are ground in a hammer mill using a screen with ⅛-inch diameter perforations. The finely ground potatoes are mixed with water and travel across two phosphorus bronze 80-mesh screens. The starch is washed through the screen while the pulp travels across the screen, and is pumped into another hammer mill using a $^{1}/_{16}$-inch diameter perforated screen. From the re-grind mill, the pulp travels across one shaker screen made of 100-mesh phosphorus bronze wire. The pulp is then discharged to waste.

The crude starch milk from the re-grind screen is used for mixing with the ground potatoes as received from the first hammer mill. The starch collected from the first grind is pumped over a third shaker of 120-mesh phosphorus bronze screen. This removes particles of peelings, dirt, and other foreign matter which may have passed through the coarser screens. After passing through the refining shaker the crude starch milk is pumped into vats, where the starch is allowed to settle for a period of at least 9 hours. The water on top of the starch is drained into the sewer and sufficient fresh water added to bring the starch into suspension by the use of paddle agitators. The starch is transferred to the re-wash tank where it remains until the following day when the wash water is again drained.

At this stage there forms a layer on the surface of the starch consisting of partially decayed starch, dirt, and fine particles of other organic matter. This layer is called the brown starch and is removed by scraping and washing with water. The brown starch is collected in a separate tank and run slowly across starch tables, which consist of two troughs, 50 feet long by 2 feet wide, with sides 1 foot high, and having a slope of 3 inches in 50 feet. As the brown starch slowly passes over the tables, the white starch settles out. The white starch obtained by this process is mixed with the remainder of the starch just before it is dried. The brown starch that has been removed from the white starch is again mixed with water and brought into suspension with paddle agitators. It is then transferred to the final settling vats where the starch is allowed to settle a third time, and the following morning the brown starch is again removed and tabled. The second layer of brown starch is usually a very thin skim. The white starch is then mixed with an equal volume of water and is ready for the final drying.

Drying Potato Starch

There is a wide variation in the methods employed for drying starch; however, most plants use one of the following systems: dry house, conveyor belt, rotary drum, or flash drying.

Two of the Idaho starch plants use a modified rotary drum drying system, and the plant at St. Anthony has developed an original flash-type system. In the rotary drum system, the starch is prepared for final drying by suspension in clean water, using approximately 40 percent water to 60 percent starch, which is pumped to the centrifuges. Here the moisture content is reduced within a range of 38 percent to 42 percent water. After partial dewatering, the wet starch is fed into the rotary drum drier by means of heated pneumatic conveyors.

The Idaho plants use Hershey-type driers similar to those used by the beet sugar industry. These drums are about 6 feet in diameter. The revolving drum is equipped with fins for uniform distribution of the starch so that as the drum turns, a continuous sheet of starch falls through the hot air. The hot air is introduced at the starch discharge end of the drum and escapes at the feed end. This system produces a dried starch with more powder and fewer lumps than either the dry house or the conveyor belt systems; but it is still necessary to pulverize and sieve the dried starch in order to get a uniform powdered product.

In the flash drying system the starch is handled the same as for the conveyor belt or the rotary drum systems. It is pumped from the last settling vats into a continuous Oliver filter. The blade on the filter cuts a thin layer about ⅛-inch thick and the starch falls into a conveyor mounted on the side of the filter drum. The screw conveyor drops the starch into a high speed blower where it is mixed with air at 320° Fahrenheit. The moisture laden air and wet starch are separated in a cyclone dust collector. The air passes outside and the starch is dropped into another screw conveyor which feeds a second high speed blower. Air at 250° Fahrenheit is introduced with the starch in the number two blower. The wet air and dried starch are separated in a second cyclone. The air is passed through a dust chamber before it is expelled to the atmosphere. The dried starch, containing approximately .19 percent moisture, is deposited into a screw conveyor which carries the starch to a third blower. Number three blower uses only atmospheric air at room temperature. This blower serves the double purpose of elevating the starch to the sieve and cooling it at the same time. It also removes about 1 to 2 percent moisture from the starch. The dried starch then passes through a silk bolting cloth sieve and into the bag.

It is believed that the starch plant at St. Anthony, Idaho, is the only one in the country using this system of drying. The other two plants in Idaho use a modified rotary drum drying system. Their method is to collect the partially dried starch from the centrifuge and introduce it into a blower with hot air. The starch is then dropped into a cyclone, and from there to a revolving drum 6 feet in diameter by 23 feet long. This system requires approximately 25 minutes for the starch to reach the bag from the centrifuge.

Construction Details of the Flash Drier

The design of the flash system of drying at the St. Anthony plant was based on the following requirements:

1. Drier to have a capacity of 1,000 pounds of starch containing 18 percent moisture per hour.
2. Starch from vacuum filter to contain not more than 42 percent moisture.
3. Number 1 blower to remove 15 percent of the 42 percent remaining moisture or to reduce the moisture content of the starch to 27 percent.
4. Number 2 blower to reduce moisture from 27 percent to 18 percent.
5. Number 3 blower to elevate and cool the starch.
6. Air at 320° Fahrenheit to be available from a hot air furnace.

Figure No. 3 shows the details of construction. The speeds and motor size of the three blowers are as follows:

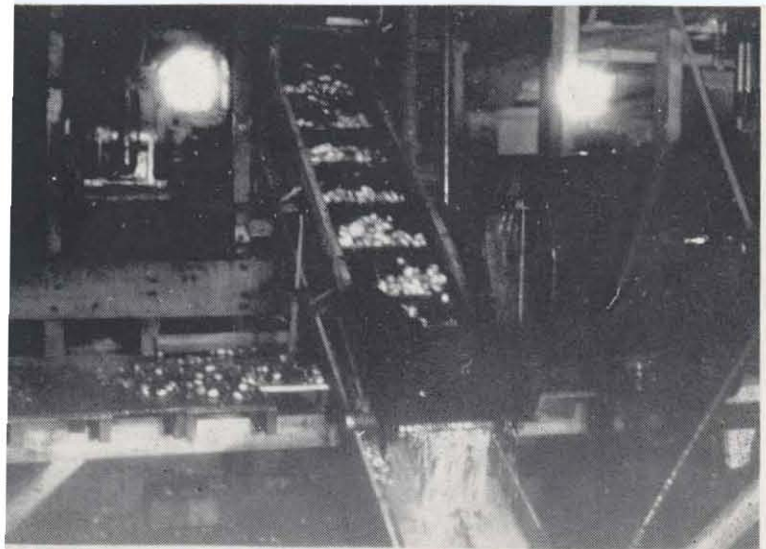
No. 1 2,300 revolutions per minute, 10 horsepower.

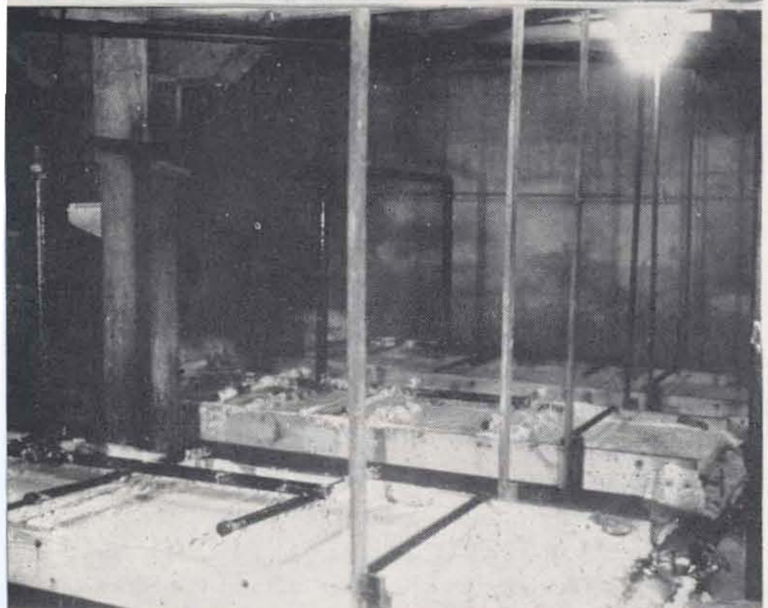
No. 2 2,000 revolutions per minute, 7½ horsepower.

No. 3 1,800 revolutions per minute, 5 horsepower.

The designs of the dust-collecting cyclones were based on the experience obtained from the installation of similar units in the Blackfoot and Twin Falls plants. The body of the cyclones were 5 feet in diameter, with the main cylinder 3 feet high fitted with a 4-foot cone, a 20-inch outlet, a 10-inch inlet, and a 12-inch discharge for the end of the cone. To prevent the blowers from drawing an excessive amount of air from the bottom of the collecting cyclones, it was necessary to provide a choke arrangement. This was accomplished by using a 4-inch auger conveyor rotating in a 5-inch tube. The cyclones discharged into the auger and tube, and the auger carried the starch to the blower. In this way very little air could be drawn from the cyclones as the starch was deposited into the blowers.

The sifter used consisted of a rotary unit with a sieve frame covered with No. 7 xx silk bolting cloth and driven by a 1-horsepower motor. One 3-ton hopper was constructed for collecting the finished product and a 500-pound capacity bin was made for the tailings from the sieve.





Illustrations ight

St. Anthony Starch Cany, St. Anthony, Idaho.

Flash drier, St. Anth starch plant, showing arrangement of the blowed cyclones.

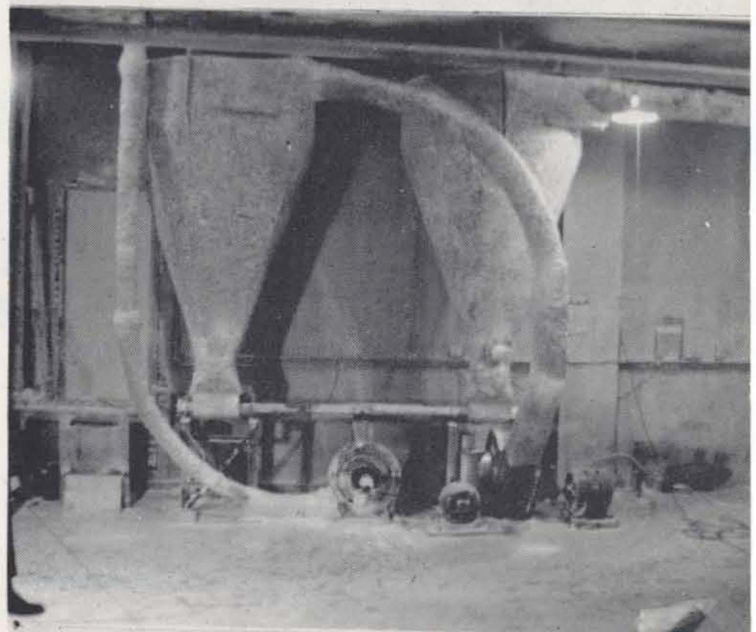
Oliver vacuum filter, St thony starch plant.

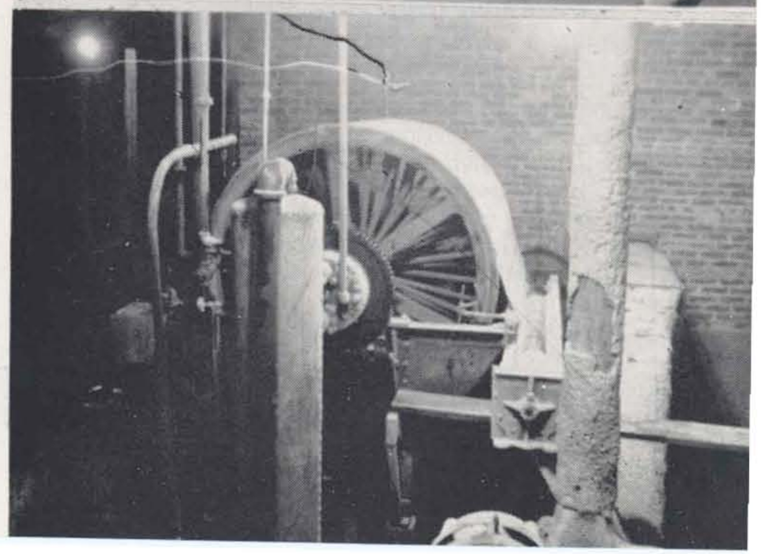
Ilrations at left

Potatoes on elevator froasher to grinder.

Re-grind shaker screen iegground.

Re-wash table shaker.





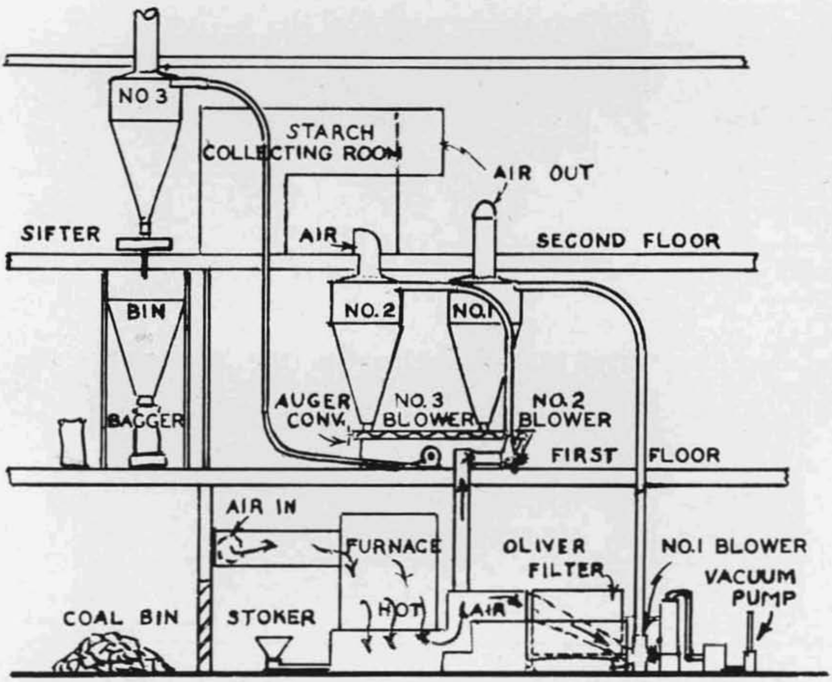


Figure 3.—Construction details of flash drier.

Drying Costs

The cost of drying potato starch depends on many factors, some of which are the following:

1. Method of drying used.
2. Capacity of drying unit.
3. Percent of full capacity at which drier is operated.
4. Condition of equipment.
5. Cost of fuel, power, and labor.
6. Type of fuel used.
7. Capital investment required.

In order to make a comparison of the drying costs for the different systems it is necessary to reduce such variable factors as the prices of coal, power, and labor to a common basis. For example, coal in Maine costs from $12.00 to $14.00 per ton, while in Idaho the cost is $5.00 to $6.00 per ton. Electric power at one plant in Maine averaged 4 cents per kilowatt-hour, while in Idaho the cost averaged from 1 to 2 cents per kilowatt-hour. Table No. 1 shows comparison of cost on this basis.

For any single system, no other factor affects the cost as much as the ratio of the full use capacity of the drying unit. For example, the flash drying system used at the St. Anthony plant has a 10-ton per day capacity. Due to the lack of raw material, this plant was not

Table 1.—Drying Costs at Idaho Plants.

Method	Man hours labor per ton	Kilowatt-hours per ton	Pounds of coal per ton
Combination flash and rotary drum[1]	2.52	55.5	244
Combination flash and rotary drum[2]	3.98	49.5	400
Flash system[3]	6.93	40.4	341

[1]Data based on actual production of 1,500 tons of starch at the Blackfoot, Idaho, plant.
[2]Data based on actual production of 872 tons of starch at the Twin Falls, Idaho, plant.
[3]Data based on actual production of 451 tons of starch at the St. Anthony, Idaho, plant.

operated at full capacity any month during the season. The production for the season of 1942-43 during November was 112.2 tons; December, 139.6 tons; and January, 206.1 tons. The unit costs were as follows:

Month	Kilowatt-hours per ton	Man hours per ton	Pounds of coal per ton
November	48.8	8.3	350
December	41.4	6.8	344
January	31.1	5.7	330

This shows a reduction in costs from November to January of 35 percent in power, 31 percent in labor, and 17.5 percent in fuel.

Assuming full capacity operation of any individual system, there is still a considerable variation in costs depending upon the capacity of the unit being considered. This factor especially affects labor costs. For instance, a 15-ton per day flash drying unit would operate at much lower unit costs than a 10-ton plant. Any 15-ton per day plant, regardless of system used, should show less unit labor cost than a 10-ton drier. The plants at Blackfoot and Twin Falls have similar driers, but the plant at Blackfoot, operating at 15 tons per day, reported a unit labor cost of 2.52 man hours per ton, while the plant at Twin Falls, operating at 10.5 tons per day, reported a labor charge of 3.98 man hours per ton.

In comparing the flash drying system with the other systems listed, the greatest advantage of this method of drying is that it requires less capital investment per unit of capacity. The combination system used at the Blackfoot and Twin Falls plants required approximately $1,000 capital investment per ton capacity for the drying units. The flash system at the St. Anthony plant only required $582 per ton, or a saving of approximately 42 percent. Another advantage is that the flash drying system requires less coal per ton of starch produced than any of the other systems, with the exception of the one at Blackfoot.

The figures reported show that the flash system saves 55.5 percent of coal over the dry house method; 34.4 percent compared to the rotary drum method; 41 percent over the conveyor belt method; and 15 percent over the combination system of flash and drum drying at the Twin Falls plant. The Blackfoot plant reported a saving of 28 percent compared with the fuel requirements at the St. Anthony plant. The third advantage of the flash drying system is that it offers a more flexible control of the moisture content of the fininshed product, due to the rapid movement of the starch particles.

Electric Power Requirements

The major power requirements for processing potato starch are for the grinders and drying equipment. The total connected load in electric motors averages about 150 horsepower per plant. The drying equipment at the St. Anthony plant required 48 horsepower, with 40 horsepower used on the grinder. The total connected horsepower for this plant is 139, with an average power demand of 107 kva. The peak demand of 134 kva for the overall operation of the Blackfoot plant was recorded for the 1943-1944 season.

Potato Starch Plant Operating Problems

Any starch plant has certain individual operating problems, depending upon the construction details and location of the plant. However, there are several problems which all three starch plants in Idaho have in common. These are as follows:

1. Raw material supply.
2. Waste disposal.
3. Production of uniform quality starch.
4. Efficiency of recovery of starch.
5. Replacement and upkeep of equipment.
6. Marketing.
7. By-products.

Raw Material Supply

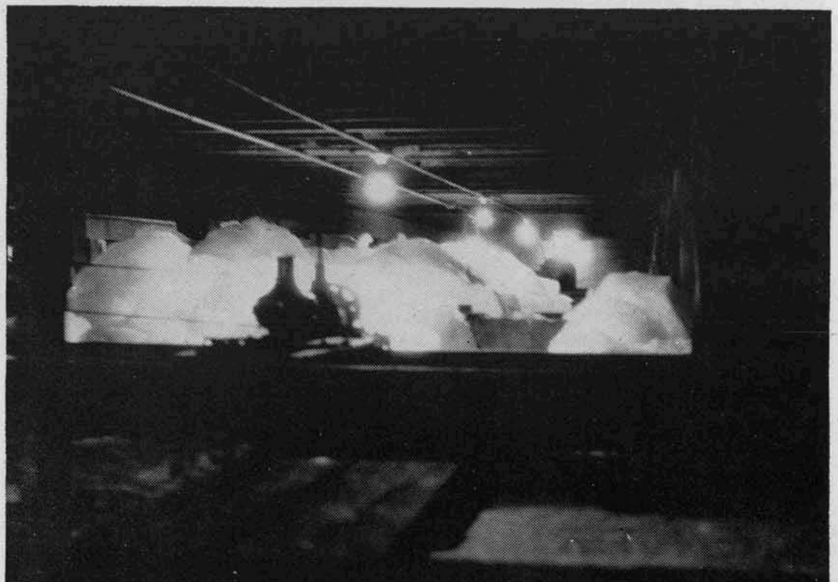
In order to assure a raw material supply and to regulate the movement of culls each plant employs a buyer. It is his job to contact the dealers and growers to maintain a steady flow of raw material to the plant. The importance of uniform flow can be appreciated when it is considered that each plant can store only a limited supply of cull potatoes. There are two reasons for so little storage capacity: one is that cull potatoes deteriorate very rapidly when concentrated in large quantities; the other is that the cost of re-handling culls from dead storage increases production costs to a questionable margin.

Potatoes are received either in bulk or sacks; in either case they are dumped into hopper bottom bins where they can be moved into the plant without further labor. Due to a shortage of bags, the trend is to haul more culls in bulk. Practically all of the culls are hauled by truck. During the 1941-42 season, the plant at Blackfoot received some culls shipped by rail from the St. Anthony territory; however, since the construction of the St. Anthony plant no rail shipments have been made. Most of the cull potatoes are purchased on a plant delivery basis. At the beginning of the 1942 season the plant at

Blackfoot and the one at St. Anthony purchased potatoes either at the cellar or at the plant. The purchase price for cellar and plant delivery of potatoes was influenced by the cost of hauling which varied from 5 to 12 cents per hundred pounds, depending upon the distance of the haul. The base price for potato delivery at the plant, ranged from 25 to 27½ cents per hundred pounds for sorter-run culls. Most of the raw material for each plant is supplied within a radius of 25 miles, but some have been moved as far as 50 miles by truck.

Waste Disposal

A serious problem in plant operations, especially at the Blackfoot and Twin Falls plants, is that of waste disposal. Both plants are located practically one-half mile from the waste disposal outlet. The plant at St. Anthony is more fortunate in being located about 150 feet from the river and having a gravity drain. The other plants are required to pump the waste disposal which consists of approximately 500,000 gallons of wash water and the pulp from 80 tons of potatoes daily. The waste protein water from the first settling vats and the protein water in the waste pulp cause most of the waste disposal difficulty due to their foaming characteristics. The foaming causes a back pressure in the sewer line and prevents a free flow of the remaining waste. It has been necessary to use sprays to reduce the foaming and to exercise much caution in preventing strings, clips, and other foreign material from entering the sewer.



Foam formation on protein water tanks.

Production of Quality Starch

The third problem, that of the production of uniform quality starch, is one which requires much attention. If shaker beds, pumps, pipe lines, and vats are not kept clean, a slime growth accumulates and causes excessive specks in the finished product. In order to overcome this problem, the plants have been using a disinfectant in their pipe lines, pumps, and shaker beds, in addition to thorough cleaning with a high pressure stream of water. Another source of trouble affecting the quality of the finished product is the proportion of rotten potatoes used. It has been found that by careful control of other sources of contamination a proportion of 20 percent rot may be used without serious damage to the starch. Above this percentage there is an excessive amount of specks in the finished product regardless of precaution used in processing.

The Idaho factories are continually improving their equipment for quality processing. Two of the plants have installed protein separators for the purpose of reducing labor costs and producing a high quality starch adapted to food uses.

Efficient Recovery

The fourth problem, that of the efficiency of recovery, affects the net income more than any other factor. By efficiency of recovery is meant the proportion of the starch recovered compared to the total available. The Idaho cull potato will contain from 14 to 16 percent starch. If all of the starch could be recovered, the yield would be from 16.5 to 18.5 pounds of starch at 18 percent moisture for each 100 pounds of potatoes processed. The actual yield obtained in the plant varies from 11 to 15.5 pounds of starch for each 100 pounds of potatoes received. When it is considered that a pound of finished starch is worth $0.0485, the importance of recovery can be appreciated.

There are three sources of loss in the plant: the first, and greatest, is in the pulp after it passes over the re-grind shaker; the second loss is the starch which goes to waste when the brown starch tank is emptied; the third loss is in the drier in the form of dust leaving the collecting cyclones and some loss in the tailings on the refining sieve. The factors which affect the loss in the pulp are the fineness of grinding the potatoes, the amount of water used to wash the pulp, the cleanliness of the shaker screens, and the rate of grinding the potatoes.

Plant Maintenance

The fifth problem, that of getting repair parts for maintenance, has been difficult due to restrictions from priority regulations. However, recent regulations have allowed more liberal purchases by processors of potato starch.

Marketing

The problem of marketing has presented no immediate difficulty due to a great demand for potato starch. There is no doubt that after the war this problem will again be one of the limiting factors in the production of white potato starch in Idaho since the market outlets are such a great distance from the points of production. Another factor which has helped in marketing potato starch is the loss of imports of vast quantities of tapioca starch. Food processors have found starch from Idaho potatoes well adapted to many new uses. The research and development in this field may help to hold the domestic market when imports are again active.

By-products

Analyses of the waste materials show that the starch plants have a high percentage of soluble proteins while the materials from the dehydration plants carry a high percentage of starch, some of which have been gelatinized or converted to sugar. Three possible uses are suggested for these materials:

1. The solubles be reconverted in their present form for starch feed or fertilizer.
2. The material be used for producing high protein feed yeast.
3. The material be used for industrial alcohol fermentation.

Under the present practices of starch production and potato dehydration in Idaho, the waste products are estimated to equal the loss formerly attributed to the non-use of cull potatoes. Although the cull problem has been eliminated as far as the potato growers are concerned it remains a serious problem for the starch producer and the dehydration plants.

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Acknowledgment

The authors wish to acknowledge the cooperation of Mr. Albert Carlson, Manager, Idaho Potato Starch Company, Blackfoot, Idaho; Mr. Emmons Coleman, Magic Valley Processing Company, Twin Falls, Idaho; and Mr. R. E. Gale, Commercial Manager, Idaho Power Company, Boise, Idaho, for furnishing data.

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