NON-FOOD OUTLETS FOR POTATOES: STARCH AND FEED[1]

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About 15 per cent of the annual potato crop is made up of sub-standard potatoes not suitable for the food market because they are too large, too small, damaged, or misshapen. Probably the most economical means of utilizing cull potatoes is to feed them to livestock on the farms where the potatoes are grown. Where the livestock population is insufficient, starch manufacture has proved to be the best method of using the culls. Since most of the potato starch is used for industrial purposes, it is entirely proper for starch to be considered in an article on non-food outlets.

POTATO STARCH

Background. Potato and wheat were the principal domestic starches early in the nineteenth century. The first potato starch plant in the United States was established in New Hampshire in 1831 at Antrim. By about 1880, more than 150 potato starch factories operated in the northeastern and in several north central states. In this early period, in Maine and other states, certain varieties of potatoes were grown especially for starch manufacture. These varieties were not outstanding in their culinary quality but had high starch content. In Holland and Germany, different varieties of potatoes are still grown for tablestock than for industrial use.

During the middle of the nineteenth century and somewhat beyond, starch-making was one of the principal outlets for potatoes grown in the New England states. Except for this early period, however, potatoes have never brought a price at the starch factory that will support the cost of their production. Since the yield of starch is about one-tenth the weight of the potatoes ground, factory owners cannot pay more than about 35 cents per 100 pounds of potatoes and sell the starch for 6 to 7 cents per pound at the plant.. Notwithstanding the fact that potatoes to be used in starch production must be sold by the grower at a low price, starch making should be considered as an integral part of a healthy potato industry. Diversion of surplus and cull potatoes to the starch industry has done much to raise the quality of tablestock and establish a more orderly marketing in the potato industry, thus helping growers obtain a better price for the entire crop.

Late in the nineteenth century, potato starch lost its prime position in the general field to cornstarch, which became cheaper to make. Potato starch then came to be regarded as a specialty starch, preferred for certain uses. In the early years of this century, the number of potato starch factories declined and Aroostook County, Maine became the center of the industry.

In the recent period of the 128-year history of the American potato starch industry, an upsurge has occurred in the production of this starch. While the number of plants is not as large as it was many years ago, the newly constructed and modernized factories have a much greater total productive capacity. With the exception of four of the years, large amounts of starch were produced from each potato crop since 1940. Revival in the general usage

[1] Largely a condensation of the chapter "Potato Starch" from Potato Processing, by W. F. Talburt and Ora Smith, published by Avi Publishing Company, Westport, Connecticut (1959).

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of potato starch has made it competitive with cornstarch, to a certain extent, in several applications. Nevertheless, it must be kept in mind that over ten times as much cornstarch as potato starch is used in the United States.

Potato starch production is limited to the northern states, where the late potato crop is stored throughout the winter and early spring. It is difficult to operate a plant economically unless potatoes are available over a period of about eight months each year. The operating season or "campaign" extends from about October 1 to about June 1 the following year, to total around 200 operating days. However, it is rare that the supply of cull potatoes is sufficient and evenly distributed so that the plants can operate at capacity throughout the season.

Statistics of production. There are 23 potato starch plants in Maine, with a total productive capacity believed to exceed 250 tons of starch per day. Total production of the Maine factories first reached the vicinity of 100 million pounds of starch per year in the 1950-51 campaign. The record high was set in the 1956-57 campaign with 115-120 million pounds being produced. Starch production was lower the following year due to a reduced supply of raw material but rebounded to a high level in the 1958-59 season because of the surplus crop.

Potato starch production in Idaho was started in 1941 when plants were established at Idaho Falls and Blackfoot. Additional plants were built subsequently until the total for Idaho is now 8. These 8 plants have a combined productive capacity of approximately 265 tons of starch per day, which is of the same order as that for Maine's 23 plants. The largest potato starch plant in the United States is at Twin Falls, Idaho, with a capacity of 50 tons of starch per day.

Two modern potato starch factories were built in the west in 1954-55 — one at Moses Lake, Washington and another at Monte Vista, Colorado. The Nation's newest potato starch plants are located at Riverhead, Long Island, New York and at Grafton, North Dakota.

Methods of production. Although potatoes present more problems in handling and storing than does corn, they are decidedly easier to process for starch recovery. Potatoes are ready for grinding immediately after leaving the washer. Either a hammer mill or rasp is used to disintegrate the potato cells and liberate the starch. Sulfur dioxide is added to inhibit discoloration due to enzymatic action. Skin and fiber are then separated from the starch by passing the diluted slurry through the screens. The pulp left on the screen is reground in many plants to recover more starch. The suspension of starch in water, which passes through the screens, is further purified to remove the soluble impurities and the remaining finely-divided insoluble impurities suspended in the "starch milk." Removal of the soluble impurities is effected by resuspending the starch in fresh water and letting it settle in vats or by letting the starch settle as the suspension flows slowly along channels called "tables." Many modern plants use centrifugals to wash the starch. The wash water containing the solubles is called "protein water." The fine fiber present in the starch milk is removed by passing the suspension through successively finer screens or is discharged in the "tailings" from the tabling or centrifugal separation. The latter two methods of separating fiber from starch depend on the fact that fiber has a lower specific gravity than starch and can be floated away while the starch settles.

The purified starch milk is dewatered by vacuum filtration or by centrifugation. The dewatered starch is dried by use of any one of several types of driers.

We might consider a typical Maine factory as grinding 80 to 90 tons of potatoes per day to produce about 10 tons of starch. It should have storage facilities for at least 6,000 to 7,000 hundredweights of potatoes. The process used in one Maine plant of this size is illustrated in figure 1. The flow diagram describes the various steps in processing. Although this factory is not of the latest type, its methods are efficient and the final product is of high quality.

The average composition of potatoes processed in Maine starch factories is estimated as follows, in percentages: starch 13; protein (N x 6.25) 2; cellulosic material 1.5; sugars 0.5; mineral (ash) 1; miscellaneous minor constituents (total) 1; water 81. Potatoes received at Idaho plants contain perhaps 15-16 per cent starch.

Fractions, modifications, and derivatives of potato starch. The fractions of starch, amylose and amylopectin, are imported from Holland for use in American industry. Uses of amylose are still largely experimental, but amylopectin is of established value in sizing and thickening. Most of the potato starch is sold in the native, unmodified form. However, sizable amounts are converted into dextrin by roasting and into pregelatinized starch. Modified starches having low paste consistency are produced by treatment with acids or oxidizing agents. Several chemical derivatives of potato starch are produced commercially, such as hydroxyethyl starch which is imported from Holland for use as a thickening gum.

Potato starch uses. Maine potato starch is used in the various outlets in approximately the following percentages of total usage: paper 60; textiles 30; food, adhesives, and miscellaneous 10. It is believed that potato starch produced in other areas is used in approximately the same percentages.

In recent years potato starch and cornstarch have sold in the same price range, with potato starch bringing much of the time 6 to 6½ cents per pound at the plant. Potato starch is well liked compared to the cereal starches because its pastes are comparatively clear, have strong adhesive and cohesive power, and have less tendency to set to a rigid gel on cooling. These properties are valuable for many applications in *paper manufacture*. Potato starch is used for (1) beater sizing; (2) tub sizing of the preformed sheet; (3) calendar sizing of quality paper; and (4) surface coating of high-gloss paper. The strong adhesive power of potato starch pastes also makes this starch in demand for *textile sizing*, particularly for "warp" thread being woven into cloth. Much potato starch is also used in the *food* industry, where it appears in bakers' specialty items, as a thickener in soups and gravies, and in "instant" puddings. Most of the potato starch used as an adhesive is employed in the form of dextrin. Potato dextrin paste is quite "tacky" and gives a flexible residual film that remoistens easily.

Starch outlook. This industry has made much progress in the past 15-20 years in furnishing consumers with higher quality starch and in adequate quantity. It is quite difficult to forecast how fluctuations in the size of future potato crops will affect the volume of starch production. Many leaders in the potato industry, though, predict that closer grading of food potatoes in the future will assure an ample supply of culls for starch manufacture.

LIVESTOCK FEEDING OF POTATOES

The exact quantity of potatoes fed to livestock each year is unknown, but it is perhaps 5 per cent of the crop on an average. The volume of potatoes fed to livestock is dependent on several factors, such as the supply available for an extended period, price of the potatoes relative to competing feedstuffs, and transportation costs

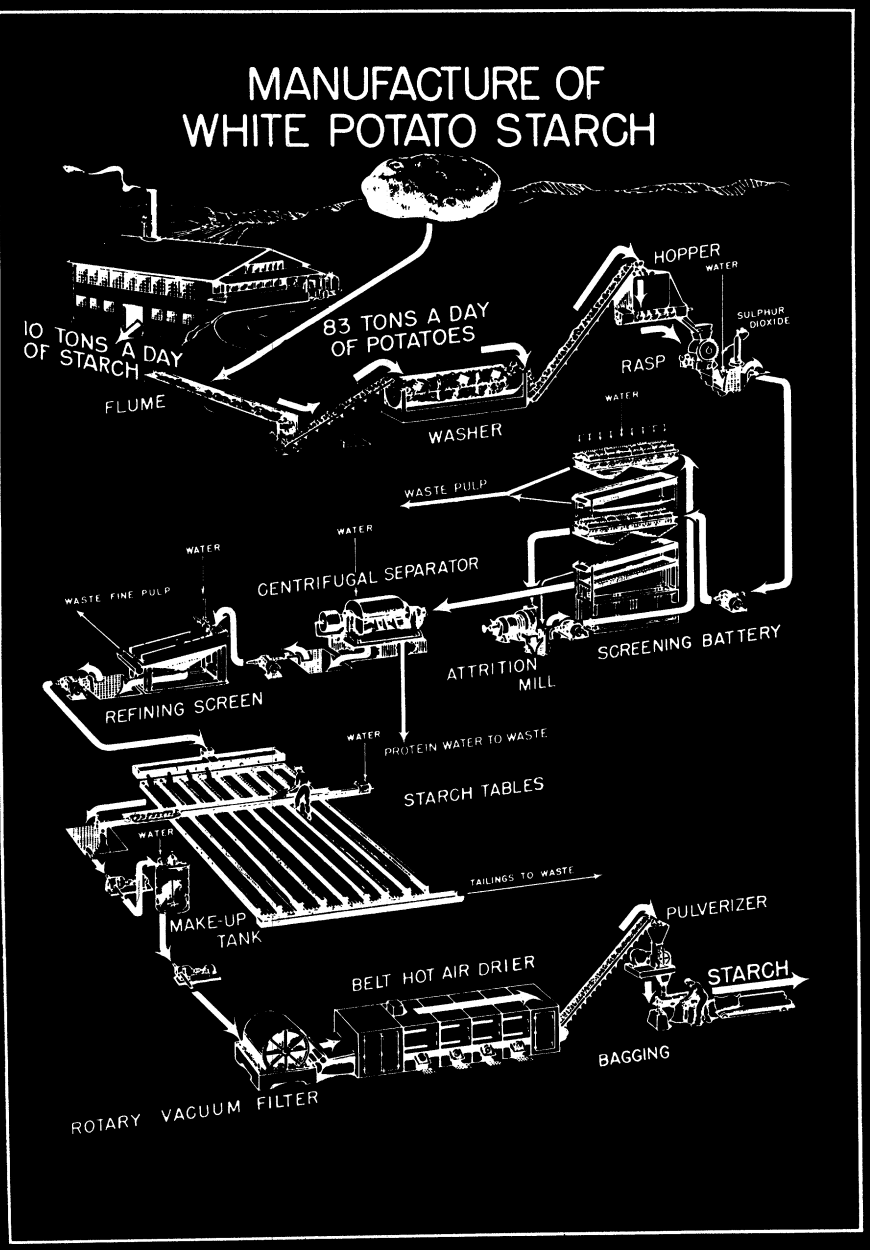

FIGURE 1.—Manufacture of potato starch as practiced in one Maine plant.

from the potato-producing area to the feeding area. During years of surplus potato crops, the United States Department of Agriculture has encouraged the feeding of certain lower grades by allowing payments to growers who diverted such supplies.

Potatoes are fed in combination with other feedstuffs to make a well-balanced ration. They are fed fresh

and in the ensiled and dehydrated forms that can be stored. Potatoes dried under conditions in which they lose but little juice are nearly equivalent to corn in feed value. Such dried potato feed (10 per cent moisture) contains typically about 75 per cent carbohydrate and 9 per cent protein (N x 6.25) and will replace about 4½ times its weight in fresh potatoes.

Potatoes are usually cooked before feeding to hogs, but they are successfully fed raw to cattle and sheep. Pigs are fed from 1 to 5 pounds of potatoes daily, the amount varying with body weight. Cooked potato silage and dried meal also are good feeds for swine. Steers and dairy cattle have been fed up to 60 pounds of fresh potatoes per day, the tubers usually being chopped or ground in advance. With lambs, potatoes are fed at the rate of 1 to 2 pounds daily per animal, along with legume hay and grain. Potatoes in various forms have been fed successfully also to turkeys, ducks, chickens, horses, and mules.

Although the ensiling of potatoes is not widely practiced at present, culls are dehydrated by natural means to produce dried feed in large tonnages. Sun drying of cracked potatoes spread on idle airport runways is a well-established method in Kern County, California. Natural freeze drying of potatoes spread on the ground during the winter months is satisfactorily practiced in North Dakota and Minnesota. Mechanical dehydration to produce potato meal is technically feasible but has not been extensively carried out commercially.

The extracted pulp from Maine potato starch factories is pressed and dried for sale as a feed component. This feed is high in carbohydrate but lower in protein than are whole dehydrated potatoes. In other areas the pressed pulp is fed in the wet form as received from the starch plant, or after ensiling.

In conclusion, the feeding of cull and surplus potatoes to livestock is an excellent means of utilization in locations where the animal population is adequate. Fresh, ensiled, and dehydrated potatoes are unquestionably of good value as feeds.