NEWS AND REVIEWS

RECENT DEVELOPMENTS IN PROCESSED POTATO PRODUCTS[1]

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UTILIZATION PICTURE DURING PAST 10 YEARS

Most of the potato crops in the period 1944-1950 resulted in substantial surpluses. Smaller surpluses have occurred in several of the crops since 1950. A surplus of about 42.5 million bushels over the 339 million goal was indicated by the 1955 Crop Report. However, diversion of surplus potatoes to starch and feed placed the figure for total utilization plus shrinkage near the figure for total production. "Total utilization" is defined as the sum of the quantities of potatoes consumed as food, seed, feed, and in the nonfood industrial outlets. The term "shrinkage" is used in the usual sense to denote the weight loss and normal spoilage to be expected during storage (Figure 1).

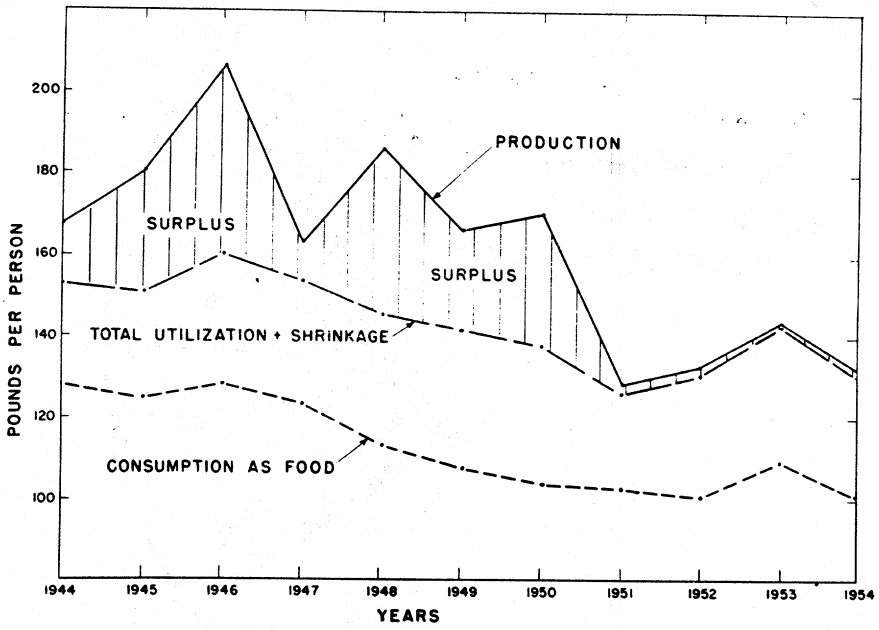

FIGURE 1.—Consumption of potatoes, total utilization plus shrinkage, and production on *per capita* basis for 1944-1954 crops.
Sources: Agricultural Statistics, published yearly by the U. S. Department of Agriculture, Washington, D. C.; Agricultural Marketing Service, U. S. Department of Agriculture, Washington, D. C. (tentative data for 1953 and 1954).

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The 1954 crop, furnishing 351 million bushels for domestic use, was approximately in balance with the total requirement. The U. S. Department of Agriculture Marketing Service estimates that the 1954 crop was utilized in approximately the following way: food use in the ordinary fresh form: 236.5 million bushels or 67 per cent of the total; processed foods: 42 million bushels, 12 per cent of the total; nonfood uses: 40 million bushels, about 12 per cent of the total; seed: 32.5 million bushels, 9 per cent of the total (Figure 2).

The total food use, both in fresh and processed forms, accounted for 79 per cent of the entire 1954 crop. The curve for quantity of potatoes processed into various prepared foods shows a regular increase during the past 7 crop years (Figure 3).

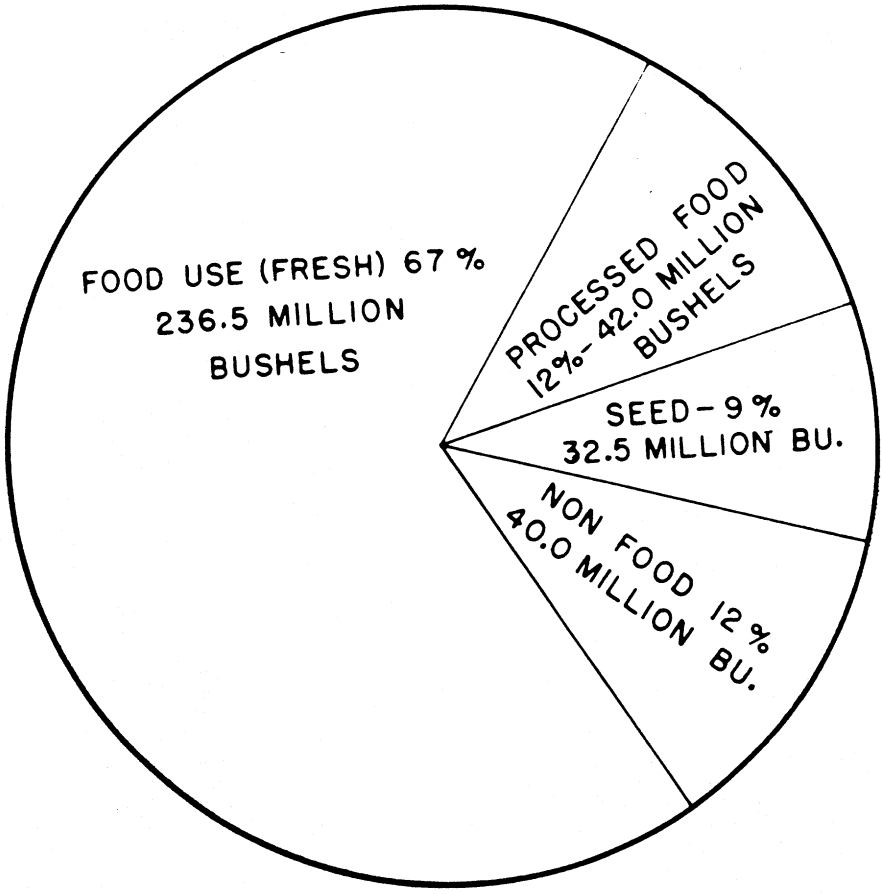

FIGURE 2.—Fractions of 1954 crop used in major outlets.
Source: Agricultural Marketing Service, U. S. Department of Agriculture, Washington, D. C. (Tentative estimates).

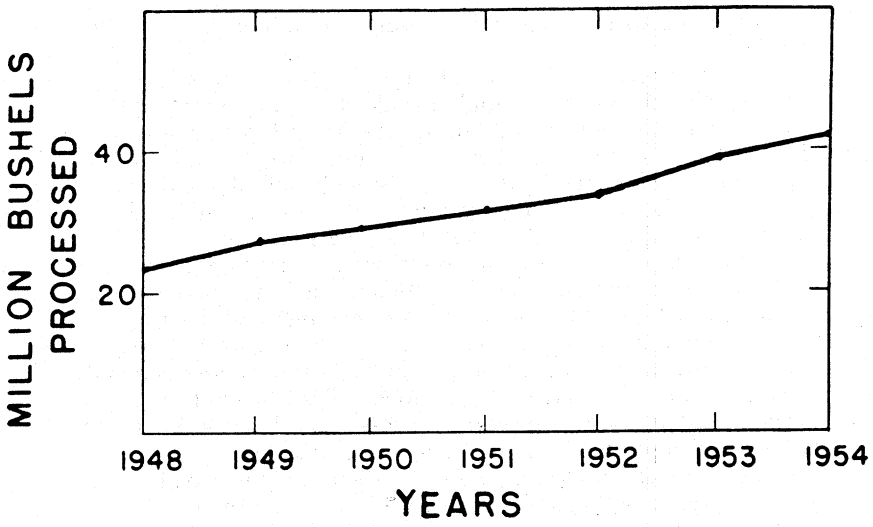

FIGURE 3.—Rate of increase in quantity of potatoes processed for food during 1948-1954.
Source: From the industries involved and from Agricultural Marketing Service, U. S. Department of Agriculture, Washington, D. C. (Tentative data for 1953 and 1954.)

The total quantity of potatoes processed for food is now double what it was in 1948 and 9 times that of 1940. The volume of potatoes used in the fresh form in households has declined drastically during the last 15 years. The amount of potatoes used by restaurants and institutions has slowly but steadily increased during this period. However, if it were not for the accelerating demand for processed potatoes, *per capita* consumption would have fallen to a ruinously low level and markets would have been chaotic. If *per capita* consumption has finally been stabilized as it seems to be, then increasing demand for potatoes due to our continuous rise will assure a future market for growers.

PROCESSED PRODUCTS

Detailed utilization data for the 1954 potato crop, as estimated tentatively by the Agricultural Marketing Service, indicate the following breakdown into various outlets (in 1,000 bushels): chips 32,000; frozen French fries 3,600; dehydrated products (mostly dice) 3,000; potatoes canned in brine pack, soups, and potato-meat mixtures 2,400; flour 1,000. The preceding individual outlets total 42 million bushels. In addition, approximately 3.2 million bushels of potatoes are used in the central peeling industry each year. The latter estimate was made in 1953, the latest year for which figures were published (6).

It is estimated* that nearly 48 million bushels of 1955 crop potatoes were used in food processing, exclusive of the pre-peeled potatoes used by restaurants. Biggest single gain over 1954 was the 4-million bushel

*Estimate made by A. E. Mercker, Agricultural Marketing Service, U. S. Department of Agriculture, Washington, D. C. (Based on data from industry.)

increase in chips. Frozen potato products gained almost 1 million bushels in their total requirement.

In the nonfood field, starch is by far the most important product made from potatoes. Ordinarily about 15 million bushels of cull potatoes are used annually in the production of starch. In the record production season of 1950-51, about 25 million bushels of potatoes were used to produce 150 million pounds of starch (10). The Agricultural Marketing Service recently estimated that the starch industry consumed 24 million bushels of the 1955 potato crop. (Based on data from the industry.)

Chips. The phenomenal growth of the chip industry is a familiar story to every potato grower. The general rule has been a definite increase each year in the quantity of potatoes used in chip making and in the average *per capita* consumption of chips (Table 1). The success of the chip industry is due mainly to the attractiveness of the product and the desire of the American people for ready-prepared foods. The chip industry is well organized and merchandises its product aggressively. This product has high food value and is appealing in flavor, texture, and color.

Color control is the most important single problem in chip manufacture. High content of reducing sugars, which react with the nonprotein nitrogen compounds, is believed to be the principal cause of excessive browning during frying. Reducing-sugar content increases during cold storage and is usually lowered by reconditioning the tubers for several days to a few weeks at approximately 70° F. Better color control is an important objective of research supported by the United States Department of Agriculture. Much of the potato research conducted by the Federal Government and by the State Experiment Stations is concerned with the relation of variety, cultural history, storage conditions, composition, and physical properties of potatoes to the quality of chips made from them. A survey, results of which were recently announced by Dr. Ora Smith of Cornell University, shows that more than 450 research projects in 35 states and 9 Canadian provinces are related to potato chips. The chip manufacturers and associated firms are also organized in a Production and Technical Committee that promotes research and development by initiating needed studies and by acting as a clearing house for exchange of available technical information.

Next to the prime requirement that potatoes for chip manufacture have low reducing-sugar content, high total solids content (high specific

TABLE 1.—*Potato Chips.*

Year	Potatoes used (1000 Bus.)	Pounds *Per Capita* Consumption Chips
1946	15,414	1.8
1948	17,200	1.91
1950	21,200	2.17
1952	24,375	2.35
1954	32,000	2.6
1955	36,000	2.88

References: 1946-1952 data from National Potato Chip Institute; 1954 and 1955 potato consumption figures (tentative) from the U. S. Dept. of Agr. Marketing Service.

gravity) is also desirable. Chippers prefer such potatoes because they give a better yield of chips and absorb less fat during frying.

Most of the chips processed are for sale in the common form. There is a limited demand for specialties such as barbeque-flavored chips, cheese-flavored chips, crinkle-slice chips, and small size chips packaged for individual servings in restaurants. Evidently the trend is toward the sale of an increasing quantity of chips in large packages in the supermarkets. Chips have passed from the snack category, exclusively, to the status of a staple food.

In spite of the impressive success of chips, there is still need for quality improvement and for process streamlining. Chips will be even more wholesome and attractive when they are produced virtually free of defective tissue. When old, stored potatoes are used, the chips are occasionally unsightly, with dark-outlined cavities. These cavities mark the places where defective tissue was present in the potatoes. When the slices reached the hot oil bath, this soft, decayed material was removed by the shock of frying.

The objective of a cooperative project between the Eastern Utilization Research Branch and a large chipper is to streamline the prefrying operations. Efficient means are to be developed for furnishing high-quality potato slices to the fryer. Three additional steps are being put into the processing line, which are innovations in the ordinary potato-chip plant. These new steps are: (A) Soaking and then washing the potatoes before peeling them; (B) Inspection following peeling to separate those potatoes requiring trimming from good raw material going directly to the final processing; (C) Trimming all separated potatoes containing bad spots. Slicing and frying would be carried out in the usual manner. Slices about 1/20-inch thick are washed to remove free starch, after which the slices are drained and then fried in continuous fryers where they remain for two to three minutes in fat at 375°-425° F.

Several experimental products have been developed recently by the Eastern and Western Utilization Research Branches that either use chips or are prepared by methods similar to those of chip making. These include potato chip bars (11), crushed chip candy products, potato "chiplets," and "potato nuts." Chip bars are prepared by compressing crushed chips into self-supporting pieces. Several different types of candy, containing chip pieces ⅛ to ¼ inch on a side, have been prepared. Two of the better formulations combine about ⅓ part by weight crushed chips with 2/3 part chocolate or hard brittle mixture to produce a "crunch" bar type of candy. "Chiplets" are made from potato strips about 3/32 by ½ by ½ inch that are dried and then partially reconstituted in water before frying. "Potato nuts" are made by frying dice about ¼ inch on a side in deep fat. None of these products is made commercially at present, but potato chip bars are in standby status as a possible ration for the armed forces.

Frozen Products. French fries are by far the most important potato product that is frozen. The National Association of Frozen Food Packers estimates that French fries comprised 60 million pounds of the total 71 million pounds of frozen potato products produced in 1953. Total production of frozen potato products has grown much since 1953, reaching 183 million pounds in 1955 according to an Agricultural Marketing

Service survey. Frozen French fries became a commercial product shortly after the close of World War II. Since then the line of frozen products has been extended to include puffs, dice, patties, soup, and whipped potatoes (Table 2). The demand for frozen French fries has regularly increased, and the industry used an estimated 4,200,000 bushels of potatoes from the 1955 crop.

The quality requirements in raw material for French fries are about the same as for chips. In addition to color control, however, texture is also a problem with frozen French fries. French fry strips that are soft and soggy at the center after the finish heating or frying give a bad impression. Soft centers of fried strips are thought to be associated with low total solids content more than with any other single factor. Although frozen French fried potatoes are not uniformly of as high quality as processors would like, they are increasingly popular with the public because of the convenience they offer.

In the processing of French fries, clean peeled potatoes are sliced into strips of ⅜- or ½-inch square cross section. The slices are washed to remove free starch, and small slivers are removed by passing the pieces through a revolving "squirrel cage" sorter. These small pieces can be used for panfried potatoes in restaurants, for patties, soup, or for making mashed potatoes. Frying in the processing plant is often done in two stages. This permits separation of slices that stick together during the first fry. Some processors, however, fry in a single step and depend on turbulence in the bath or on some sort of stirring or tumbling to keep the slices from sticking together. Frying temperatures and times differ from plant to plant and with different raw material. In addition to reduction of frying temperature when necessary, color is also controlled by a one-to-two minute hot water blanching before frying. In some processing plants all raw material is water blanched and, where necessary, a subsequent dip in glucose solution is carried out to obtain the desired degree of browning. Some processors freeze French fries before packaging and others, after. A large fraction of the frozen French fries

TABLE 2.—*Frozen potato products.*

Total Quantity Processed (Mainly French Fries)*

Year	Potatoes Used (1000 Bus.)
1950	1200
1952	2750
1954	3600
1955	4200

Forms Other Than French Fries
Puffs — Mashed potatoes, flour, egg, seasoning (fried)
Blanched Dice — For hash browning
Patties — Shredded potatoes, flour, seasoning (formed)
Soup — Small potato pieces in flavored creamed base
Whipped — Well-beaten mashed potatoes

*Data from Agricultural Marketing Service, U. S. Dept. of Agr., Washington, D. C.; 1954 and 1955 figures tentative.

produced are sold for household use. Housewives prepare the product for the table by warming in the oven. Restaurants prepare the frozen product by frying for one to two minutes at 375° F.

"Par-fried" sliced potatoes are processed to a limited extent for the restaurant market. The par fries are fried only to the light brown stage. This partial frying destroys the enzyme system responsible for discoloration and provides a product that can be held at least one week under refrigeration. Frying is completed in the restaurant kitchen in approximately one minute in 350°-400° F. fat.

Frozen fried potato puffs and frozen whipped potatoes are usually made from the small pieces sorted out in the processing of French fry slices. The slivers are steamed and mashed. For whipped potatoes, the mash is vigorously beaten before freezing. For producing puffs the mash is mixed with wheat flour, eggs, and seasoning. This mixture is formed into croquettes and fried in deep fat before freezing.

Frozen diced potatoes for hash browning have been on the market several years. The potatoes are sliced into cubes about ⅜ inch on a side, steam blanched, and then frozen. Onion flavoring is sometimes added before freezing to complete the processing. This product is cooked by frying in a skillet.

Frozen potato patties have been on the market for the past two years. Peeled potatoes are shredded, blanched, mixed with flour and shortening, and shaped into circular or rectangular pancakes. These patties, weighing about 3 ounces each, may be fried in deep fat or in a pan.

Canned frozen cream of potato soup has appeared in the retail markets during the past two years. This soup contains small pieces as well as mashed potatoes. Frozen potato soup has been well received by consumers because the flavor is far superior to that of ordinary canned potato soup.

Pre-Peeled Potatoes. Pre-peeled potatoes were first made available in the dry form about 1936 (12). The industry grew slowly until 1947 when it entered a rapid-expansion phase. A survey made by the U. S. Department of Agriculture Marketing Service indicated that 120 peeling plants were operating in 1954 in 32 states and the District of Columbia (6). Most of the plants are in metropolitan areas. A few of the processors produce peeled potatoes for the retail trade but the preponderance of the total volume is distributed in wholesale channels.

Restaurateurs and operators of institutional cafeterias pay 3 to 6 cents a pound above the price of unpeeled potatoes for the pre-peeled product because they save labor, space, equipment expense, and avoid certain troubles in procuring good raw material. The service that the purchaser of pre-peeled potatoes obtains in securing high quality potatoes suitable for his purpose is as important to him as the fact that they are already peeled.

Peeling plant operators prefer large, uniform-shaped potatoes with shallow eyes and no defects. They are generally indifferent to variety although some favor Idaho Russet Burbank.

The general scheme for processing pre-peeled potatoes is given in figure 4. Although abrasion is the most common peeling method employed, lye peeling is also used. In lye peeling the potatoes are dipped in hot

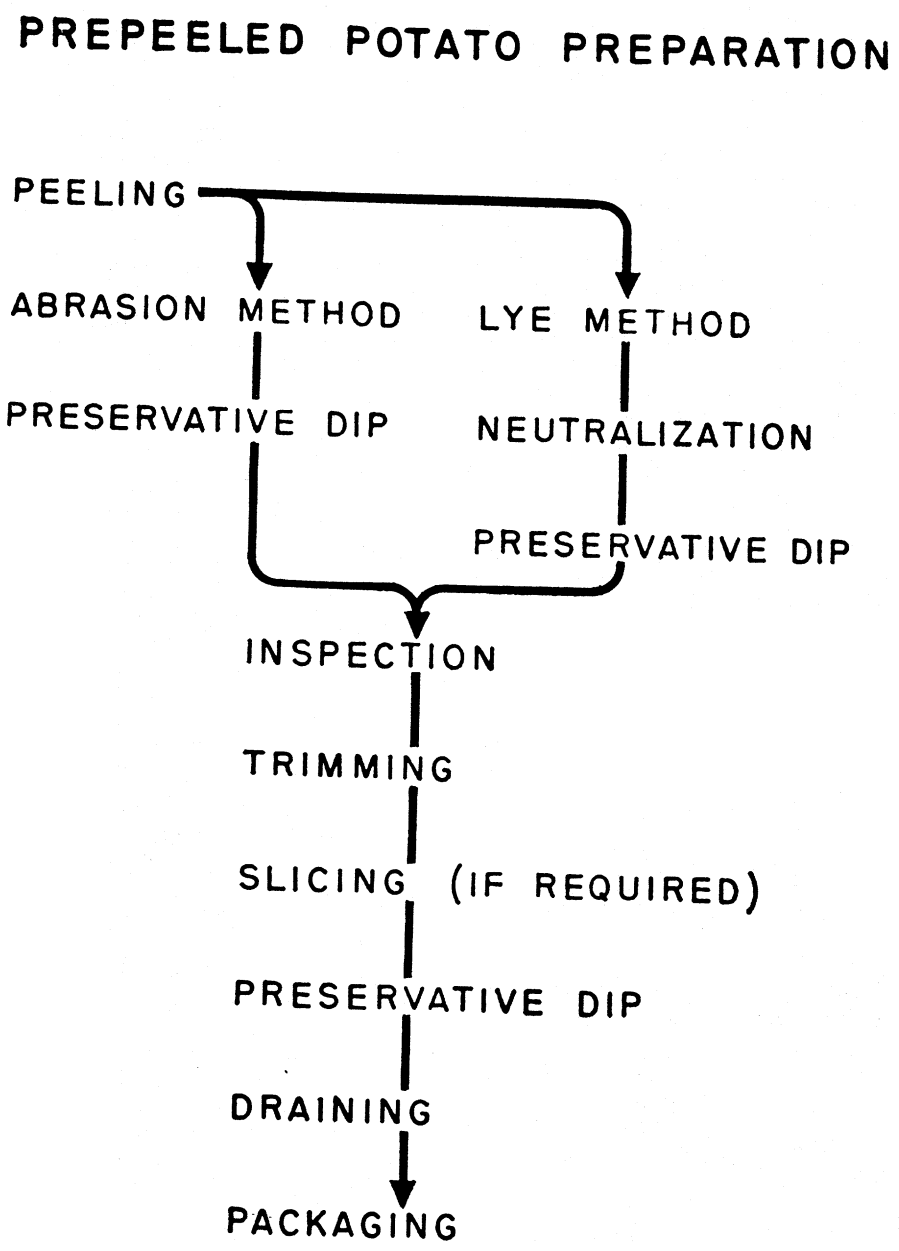

FIGURE 4.—Processing of prepeeled potatoes.

sodium hydroxide solution, which loosens the skins by thermal shock and chemical action. The lye-affected tissue is then removed by rigorous washing usually accompanied by rubbing or brushing the surface. Apparently few central peeling plants use steam peeling.

High temperature peeling operations (steam and lye) must be closely controlled to avoid cooking the potato tissue to excessive depth. This would be unobjectionable in potatoes that are to be cooked immediately in a food processing plant, but a cooked surface is undesirable in a product to be merchandised as raw, pre-peeled potatoes. Recent research by the Western Utilization Research Branch of the U. S. Department of Agriculture, Albany 10, California, in cooperation with a California central peeling plant, indicates that use of 15-20 per cent sodium hydroxide solution over the temperature range 130-140° F. gives good peeling efficiency without forming the cooked layer that is obtained in very hot lye solutions.

Following the peeling, it is the common procedure to dip the potatoes in dilute sodium bisulfite-acid solution to prevent discoloration during subsequent processing. Regardless of the peeling method, the remaining bits of skin and dark spots are removed by hand trimming as the potatoes move along an inspection table.

A second dip in dilute sodium bisulfite solution, usually containing a small amount of acid such as citric, preserves the original whiteness of peeled potatoes for a week or so until used by the restaurateur. Considerable effort has been expended in searching for an effective treating agent other than sulfite since the latter imparts a slight off-flavor and its use is banned in a few states. However, no other effective treating agent is available to date that is feasible from the standpoints of low cost and freedom from toxicity.

Following treatment to preserve the color, pre-peeled potatoes are quickly cooled to 32°-40° F. and stored in this temperature range until used. The product is usually packaged in a container that excludes air and prevents loss of moisture.

There is apparently room for much expansion in the pre-peeled potato industry. Only a few areas at present are well covered in the distribution of this product.

Dehydrated Potatoes. By far, most of the potatoes dehydrated are in the form or *dice*. The biggest market for dice is in the canning of stews and hashes. Many of the meat packers now use dice instead of fresh potatoes in their canned potato-meat products.

In processing dice, the potatoes are peeled by the lye or steam methods. After trimming, the potatoes are sliced to the desired piece size. Pieces ⅜ by ⅜ by 3/16-inch ("half dice") are perhaps the most commonly dehydrated. Blanching of the dice is carried out in a continuous steam blancher. The dice may be sulfited before drying, or sulfur dioxide may be present in the flue gas that passes over the trays during the drying operation.

A major problem in dice manufacture is the prevention of excessive browning during production and storage. The Western Utilization Research Branch has devoted much attention to the importance of drying conditions and to the effects of temperature and moisture content during storage of the product. The ⅜ by ⅜ by 3/16-inch piece is usually

dehydrated to 7 per cent moisture content. It was recently found by the Western Utilization Research Branch and the Food and Container Institute of the Quartermaster Corps that ⅜ by ⅜ by ⅛-inch pieces could be reduced to 5 per cent moisture as readily as the thicker pieces to 7 per cent (8). This lower moisture content enhances color stability during storage. The use of a dilute calcium chloride solution dip helps to prevent mushiness during rehydration and cooking of the pieces. Use of calcium chloride in conjunction with sulfite has also been found to give added protection against browning (9). These findings have resulted in considerable quality improvement in potato dice over that which prevailed several years ago.

Research and development in *dehydrated cooked mashed potatoes* have been active during the past few years. Many of the investigations have been concerned with improvements in the add-back method of producing potato powder in granule form. Research on *granules* has been conducted by the Western Utilization Research Branch (7), the University of North Dakota (2), the Quartermaster Food and Container Institute (2) and by companies within the industry. Particular attention has been given to minimizing abrasion and impact damage during drying in the pneumatic driers ordinarily used. New types of driers, such as improved airlift and fluidized bed driers, have been developed. Drying must be carried out to produce a powder consisting of discrete particles, both individual cells and agglomerates containing a few cells each, and rupture of these cells during processing must be avoided so as to minimize liberation of starch. Presence of free starch during reconstitution of granules results in pasty mashed potatoes.

Three plants in Idaho and one at East Grand Forks, Minnesota, produce granules. Demand for the product has been continuously on the increase since it was introduced to the civilian market in 1947. Productive capacity of the industry has been raised periodically and was substantially increased this year.

Potato flakes represent a new type of dehydrated, precooked product that offers considerable promise of achieving commercial adoption (3,4,5). In preparing flakes, a development of the Eastern Utilization Research Branch, mashed potatoes are dried in sheet form on a single or double-drum drier. The sheet is scored into small squares about ½ inch on a side to break it into flakes before packaging. Potato flakes reconstitute readily to mashed potatoes of good flavor, texture, and color. Flakes made from relatively low-solids potatoes (about 18%) absorb more water than granules do to give mashed potatoes of comparable consistency. Flakes are capable of reconstitution over a wider temperature range. High-solids potatoes are normally required for producing dehydrated products that reconstitute to a mealy mash. However, it has been found that precooking ⅝ inch thick potato slices in water at 140° to 180° F. for 15-30 minutes before final cooking at 212° F. permits the use of lower-solids potatoes than could ordinarily be used. Another finding is that water dilution of high-solids potatoes to approximately 20 per cent total solids increases the flake density and strength of the sheet obtained on a double-drum drier. However, this is not necessary when a single-drum drier, equipped with spreader rolls, is used. Higher flake density means increased package density, which is important to this otherwise bulky

product, and the additional strength means less "fines" when the sheet is broken up into flakes for packaging.

Potato shreds that reconstitute to mashed potatoes are being marketed by a large food products manufacturer in several metropolitan areas. Riced potatoes are dried in hollow cylindrical pieces ¼-inch to ¾-inch long and 1/16-inch to ⅛-inch outer diameter in the production of shreds. This product apparently is being well received by consumers.

Canned Potatoes. The canning of potatoes has grown extensively during the past 15 years. About 130 canners now pack potatoes in some form. The quantity of potatoes canned (brine pack) in 1953 was 3,096,186 cases (24 No. 2 cans each) (1). This amount may be compared with 1,471,301 cases packed in 1949 and 591,411 in 1946 (1). These statistics are on a calendar-year basis.

Utilization estimates on the crop-year basis for potatoes canned both in brine packs and in hashes, stews, soups, and salads are given in table 3 for 1950-1955. Although the quantity of brine-packed potatoes is on the increase, the total quantity of potatoes canned has hovered around 2½ million bushels in recent years.

Although potato canning is rather widespread throughout the country, the greatest tonnages are canned in Maine and in the Southeast, particularly on the Delmarva Peninsula. Extensive canning of potatoes in the Southeast undoubtedly stems from the fact that their product cannot be stored, but gives a high-quality canned pack.

Flour. This product, made by the drum drying of mashed potatoes, has grown slowly in demand since its introduction after World War I. It is still used principally in the baking industry in potato bread, in prepared doughnut mixes, and in specialty items.

Starch. Considerable technological progress has been made in the potato starch industry in the past few years. Maine has more starch plants than Idaho, but Idaho's large, modern factories turn out nearly as much starch as Maine's plants do. About two years ago, a modern starch plant was established at Monte Vista, Colorado. Still more recently, a large

TABLE 3.—*Production data for canned potatoes.*

Brine-Packed (Small Whole or Slices) and Other (Hashed, Stews, Soups, Salads) for 1950-1955.

Fresh Potatoes (1000 bushels)

Crop Year	Brine Pack	Other Packs	Total
1950	865	1500	2365
1951	1000	1200	2200
1952	1430	1000	2430
1953	1550	1000	2550
1954	1600	800	2400
1955	1700	800	2500

Reference: U. S. Dept. of Agr. Marketing Service, Washington, D. C. (Data for 1953-1955 tentative).

plant was put into operation at Moses Lake, Washington. The establishment of potato starch plants is at present, under consideration in the Red River Valley of Minnesota, North Dakota, and in New York State. The manufacture and uses of potato starch were considered in a fairly recent article by the author (10).

Several changes have taken place in starch-making equipment which simplify the operations and permit the realization of large productive capacity in a small building. The screening equipment is now replaced with one new machine, which not only occupies less space, but also washes the starch to some extent and discharges pulp at 15 per cent solids instead of the ordinary, watery pulp discharged from the screen at approximately 4 per cent solids. Two equipment manufacturers offer centrifugals that successfully replace vats and tables for washing and purifying ground and screened starch to separate skin and fiber. The use of centrifugals results in tremendous space saving.

Dewatering and drying waste pulp has long presented a problem to potato starch factory operators. A new centrifugal is available that will dewater the pulp from 4 per cent to about 20 per cent solids. Pulp at 20 per cent solids is firm and can be broken up and dried.

A few starch manufacturers now offer modified potato starches to wholesale consumers. Acid treatment is used to produce so-called "thin-boiling" starches and alkaline hypochlorite to produce oxidized or "chlorinated" starches. These modifications impart certain desired properties, such as increased paste fluidity and clarity for sizing.

Uses of potato starch have changed in recent years. Textile sizing has been replaced as the principal outlet by paper sizing. The newest volume application for potato starch is in the pregelatinized form in "instant" puddings. Potato starch, like tapioca and certain other tuber and root starches, is apparently preferred over cereal starches for these puddings that are finding enthusiastic acceptance.

Summary and Conclusions

Although the volume of potatoes used in fresh form in households has declined drastically during the past 15 years, the upsurge of processing is credited with doing much to help stabilize the market. Chips remain as the largest single outlet for potatoes by far. Hence, a principal research objective has been and continues to be the search for information as to how better chips can be made in order to increase further the demand for potatoes in this product. More new products have been commercialized recently in the frozen field than in any other category of processed potatoes. Dehydrated, prepeeled, and canned potatoes continue to absorb significant quantities of raw material. Starch production is the most important outlet for cull and surplus potatoes.

Fundamental research to obtain information on the composition of potatoes and development research on new and improved forms of dehydrated mashed potatoes have received major attention in recent years. Improvements have been effected in the manufacture of granules (mashed potato powder) and also in their quality. Potato flakes represent a new type of dehydrated, precooked product that offers considerable promise of achieving commercial adoption.

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