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RECENT RESEARCH AND DEVELOPMENT IN POTATO FLOUR AND POTATO STARCH[1]

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Potato flour and potato starch are sometimes looked upon mistakenly as being the same thing. In reality, flour is a cooked dried product containing the entire potato composition except the peel. Starch is a high purity product substantially free from all other constituents of the potato.

POTATO FLOUR

The historical background, manufacturing methods, chemical composition, and uses of potato flour were discussed in recent articles (4, 5). Therefore, this brief account will include only such portions of the cited material as believed necessary for our present purpose.

Potato flour seems to have been the first processed potato food product to reach commercial production. It was produced in the U. S. during World War I as a substitute for wheat flour. In producing flour, potatoes are peeled, cooked, dried on a drum drier, and then ground to a meal or powder.

More than 90% of the potato flour is used in the baking industry. From 2 to 6% potato flour (based on the weight of wheat flour) is used in potato bread. Addition of potato flour improves the fermentation of the dough, leading to better loaf volume and flavor. Potato crackers have recently become another important outlet for potato flour. These crackers contain 15-20% potato flour and are thin and crisp, with texture resembling potato chips. They have a tasty flavor and provide an excellent snack as such or with cheese dips, refreshing beverages and nourishing soups. Potato flour is also used in cookies, cakes, and pastries, and in prepared mixes such as those for doughnuts. Potato flour is used to a lesser extent as a "breading" agent for meats and other foodstuffs, as a thickening agent in soups and sauces, as an extender in meat loaf, and in scrambled eggs.

For many years, the demand for potato flour was stabilized at such a level as to require about 1 million hundredweights of potatoes annually as raw material. Flour production has been on the increase, however, during the past 7 years. The National Potato Council estimates that the following amounts of potatoes (millions of hundredweights) were consumed in flour production from recent crops: 1953, 0.93; 1955, 1.74; 1958, 1.86; 1959, 2.22.

Potato flour is produced in Southeastern Idaho and in the Red River Valley. The raw material is mainly culls remaining after U. S. No. 1 and

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2 potatoes have been removed. The potatoes must be in sound condition and trimmed to remove decayed tissue.

Developments. Continuing research and development are being conducted by the industry on improvement of the process, improvement of the quality of the product, and extension of the uses for potato flour. Steam peeling is the preferred method at present in flour plants rather than lye peeling. Recently Adams, Hickey, and Willard (1) found that dipping the potatoes in hot lye solution followed by a short exposure to superheated steam gave more efficient and economical peeling than either steam or lye alone.

Willard and Englar (6) have pointed out that water absorption in a wheat flour-potato flour mixture increases in direct proportion to the amount of potato flour used in the dough. By closer control of certain steps in the manufacture of potato flour, it is possible to make flour that absorbs the maximum amount of water and also to obtain uniformity in water absorption. Presumably, the condition of the starch in the flour is the principal governing factor.

The increased demand for potato flour is generally credited to the development of potato crackers and to improvment in the quality of the flour for breadmaking. While the potato flour industry is faced with problems, it is to be hoped that the use of this product will continue to grow.

Potato Starch

The historical development of the American potato starch industry, statistics of production, methods of production,, and uses for potato starch and its derivatives are discussed in recent publications (2, 3). Hence, this summary will survey this previously-covered material only to the extent necessary to provide background for discussing the most recent research and development.

The first potato starch plant in the U. S. was established at Antrim, New Hampshire, in 1831. Potato starch production expanded during the middle of the nineteenth century and then lost its prime position to corn-starch, which became cheaper to make. However, an upsurge in potato starch production occurred about 1940, and there are today more than 20 plants in Maine and more than a dozen plants in Idaho and other Western locations. Productive capacity is about equally divided between the Maine and Western plants.

Potato starch plants operate from about October 1 to about June 1 of the following year, to give a total of approximately 200 operating days. The plant operators use cull and surplus potatoes, for which they ordinarily pay about 35¢ per hundredweight. Rarely, if ever, is the supply of raw material sufficient and evenly distributed enough to permit capacity production in all plants during the entire season. A total production throughout the industry of 150 million pounds of starch per year is considered a good season. This represents the yield from grinding perhaps 15 million hundredweights of potatoes.

In producing starch, the potatoes are washed and disintegrated to a finely-divided mass. The diluted mass is then screened to separate the extracted pulp from the "starch milk" containing suspended starch and the

solubles dissolved in the processing water. The starch is further washed by passing it through centrifugals, and it is then dewatered and dried.

Several years ago it was estimated that Maine potato starch was used in its various outlets in approximately the following proportions, expressed in percentages: paper, 60; textiles, 30; food, adhesives, and miscellaneous, 10. In the absence of any utilization estimate of the output of the Western starch factories, it may be assumed that the overall use pattern is in the same range as that for Maine. In the paper industry, potato starch is used for sizing and coating. Warp sizing, thread finishing, and cloth finishing are the textile applications. Applications in the food industry are in baked goods and confections. There are manifold applications of potato starch and dextrin as adhesives and in miscellaneous uses.

New plant. While several new potato starch plants have been established in the past few years, one being built at Houlton, Maine, is attracting most attention at present. According to press reports, this plant will cost $1,720,000 and will include facilities for starch manufacture, conversion of starch to modifications, production of starch derivatives, and waste recovery and processing to byproducts. The plant will have 70,000 square feet of floor area and capacity for grinding about 8,250 hundredweights daily. The capacity to convert starch to products such as dextrin (by roasting), thin-boiling starch (by acid treatment), and oxidized starch (sodium hypochlorite treatment) is said to total 60,000 pounds daily. Converted starches are used instead of unmodified starch when it is desired to have a high concentration of starch present without encountering excessive paste consistency. Some modifications result in greater tackiness and adhesive strength. Others may result in a paste that resists setting to a gel when cooled. Still other modifications may result in increased clarity of the paste and dried film.

Modifications and derivatives. The native starch molecule is made up of many glucose units joined together. In producing modifications, there are breaks in the chains of glucose units comprising the giant starch molecule. The starch molecule is thus reduced in weight or is "degraded".

In the formation of starch derivatives, substitution of a chemical group occurs at one or more of the three hydroxyl groups in a glucose unit. The most important potato starch derivative at present is hydroxyethyl starch, made by reaction of ethylene oxide on alkali starch. The commercial hydroxyethyl tarch is prepared by low degree substitution, that is, only a small fraction of the hydroxyl groups are involved in the reaction. hydroxyethyl starch is prepared by low degree substitution, that is, only to an insoluble film. Thus it is ideally adapted for sizing synthetics and other new types of textiles, where ordinary starch lost out because of poor performance. Spun rayon, spun nylon, polyester-cellulose, and cellulose triacetate warps can be sized very satisfactorily with hydroxyethyl starch properly formulated with other ingredients. Hydroxyethyl starch can also be blended with melamine-formaldehyde and urea-formaldehyde resins for making water-resistant finishes for textiles.

Potato starch ethers, such as hydroxyethyl starch, have been imported from Holland in recent years to the extent of several million pounds annually. The necessary research and development has been done

by the American industry to permit commercial production of these derivatives in the U. S., as is now planned.

Food developments. Potato starch also has desirable properties for use in instant desserts based on pregelatinized starch. In preparing pregelatinized starch, starch is slurried in water and then heated above the gelatinization temperature to provide a heavy dough. The dough is then dried on a drum drier, the dried film is scraped off by a doctor blade, and the film is ground to a powder. In formulating an instant pudding mix, the following ingredients may be included: pregelatinized starch, sugar, flavor, color, and sodium phosphates. When cold milk is added to the dry mix, the pregelatinized starch absorbs much of the water in the milk. The phosphates coagulate the milk protein. The combined effect, attained in a few minutes, is that a soft gel is formed. The gel is sufficiently firm to retain a molded shape.

Pregelatinized starch is also good for formulating quick pie fillings, frostings, meringues, icings, instant sauces and dressings, and batters for use in the deep-fat frying of fish, meat, and poultry.

Byproducts. Recent research at the Eastern Regional Research Laboratory on methods of separating and recovering nitrogenous compounds from potato starch processing water may be commercialized in the not too distant future. While the extracted pulp from starch factories is dried to provide a high-carbohydrate feed component, no use has been made to date of the substances in the processing water. Passage of the dilute, deproteinized processing water through an ion exchange column packed with Dowex 50 resin (H^+ form) results in adsorption of the amino compounds while other constituents pass through. The absorbed amino compounds are then removed by passing a limited volume of 2 Normal ammonium hydroxide through the column. The potato amino compounds can thus be obtained in much higher concentrations than they occurred in the original liquor. The concentrated fractions are then mixed and dried to a powder. This dried powder shows promise as a food flavoring agent.

The potato processing water has also been concentrated to 50-60% total solids to give a stable concentrate rich in nitrogenous compounds, sugars, organic acids, and inorganic compounds. This concentrate has been found to be valuable as a nutrient for industrial fermentations.

Conclusions

From the above discussion of potato flour and potato starch, we see that advances are being made as the results of research and development. We expect the demand for these two products from potatoes to continue to grow.

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