[Reprinted from FOOD TECHNOLOGY, 1957, Vol. XI, No. 4, Pages 236–240]

1075

Advances in the Dehydration of Mashed Potatoes by the Flake Process[a]

James Cording, Jr., Miles J. Willard, Jr.[b]
Roderick K. Eskew and John F. Sullivan
Eastern Regional Research Laboratory,[c]
Philadelphia 18, Pennsylvania

(Manuscript received October 17, 1956)

POTATO FLAKES are a recently developed new and attractive form of dehydrated mashed potatoes. When reconstituted, they produce mashed potatoes of excellent texture, appearance, color, and flavor. Earlier papers have described the process as originally developed using a small double-drum drier *(1, 5)*, the factors controlling texture of the reconstituted mash and permitting the use of low-solids content potatoes *(2)*, and the estimated cost of commercial production based on more recent work with a larger, single-drum drier *(3, 4)*.

Data reported in this paper were obtained by operation of a larger, integrated pilot plant, embodying the predrying steps developed for texture control in earlier work, and employing a single-drum drier for the dehydration. The larger plant was required to obtain reliable data for estimation of commercial production costs and to produce large quantities of potato flakes from many varieties of potatoes for evaluation. A single-drum, rather than a double-drum, drier was chosen because of indications that it could produce a denser flake that would be less costly to package. Further, single-drum driers formerly used for potato flour manufacture are idle in some plants and are available for use in potato flake manufacture.

EXPERIMENTAL

Process and equipment. A flow sheet of the pilot-plant process is shown in Figure 1. Potatoes were peeled either by abrasion or by treatment with lye of 30° Be. (about 24% NaOH) at 150° F. (65° C.) for 4 minutes. They were hand-trimmed to remove blemishes and eyes, sliced into 5/8-inch thick slabs from which the surface starch was washed, and then precooked in water at a temperature of 165° F. (74° C.) for 20 minutes. Precooking gelatinizes the starch before the final cooking step, improves the texture of the reconstituted product, and permits the use of low-solids content potatoes *(2)*. In the pilot plant, the precooking operation was performed as pictured in Figure 2. Potato slices were weighed into tinned wire baskets, which were placed into the hot water tank at intervals and moved along at a rate to give 20 minutes precooking. Baskets were removed from the precooker and the slices were spread 2 to 3 inches deep on the stainless steel wire mesh belt of a continuous steam cooker. (Robins No. 20283 blancher.)[d] After cooking in steam at 212° F. (100° C.) for 16 to 22 minutes, depending on the solids content of the potato (lower-solids content requires longer cooking) the slices were riced through 1/4-inch holes in a Chisholm Ryder Extractor, Model F.[d] Antioxidant, emulsifier, and sulfite solutions, when used, were incorporated into the mash in a Hobart Model L-800 mixer.[d] The mash was fed to the drum drier by applicator rolls as shown in Figure 3, and the product was removed by a "doctor" knife on the opposite side of the drum (Figure 4) in the form of a thin sheet the full width of the drum. The drier used was a small replica of a commercial single-drum drier, with a drying drum 2 feet in diameter and 3 feet long, manufactured by the Overton Machine Co.,[d] Dowagiac, Michigan. The sheet was broken into pieces of size convenient for packaging by passing

Figure 2. Precooking potato slices.

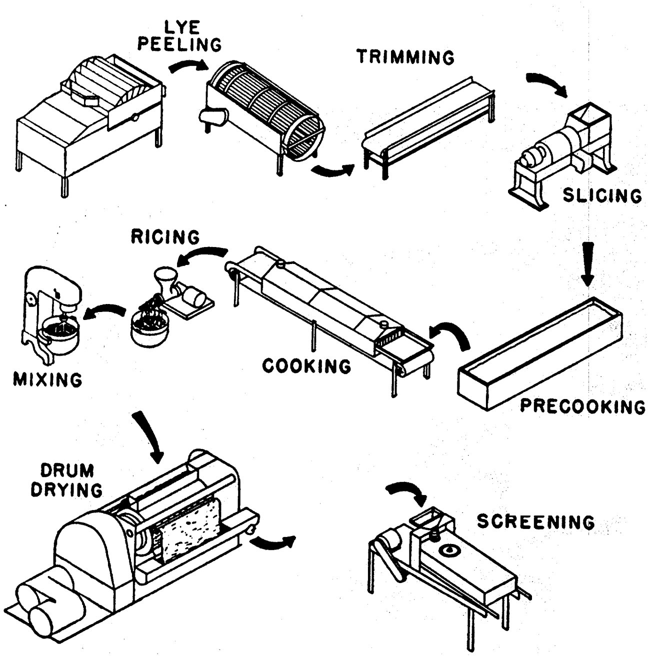

Figure 1. Flow sheet of pilot plant process.

[a] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 12, 1956.
[b] Present address: Rogers Bros. Seed Co., Idaho Falls, Idaho.
[c] A laboratory of the Eastern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

[d] Mention of trade name or company is this paper does not imply recommendation or endorsement by the U. S. D. A. over others not mentioned.

it between two rolls running in contact, one covered with 2-mesh hardware cloth and the other with rubber soft enough to permit compression of about ⅛-inch.

Procedure for obtaining drum-drier data. The speed of the drier drum was set by adjusting a variable-speed drive mechanism, and the temperature of the drum was brought to the test level by slowly increasing the steam pressure within the drum over a 15-minute period. Test conditions having been established, mash was fed to the drier until equilibrium was reached, then elapsed time was recorded for the feeding of 100-pound batches of mash. Flake production rates were taken for measured time intervals at equilibrium conditions. Solids content of the mash and of the flake was determined by analysis of composite samples taken over the period of the test, using a Brabender Moisture Tester, Type FRA.[d] Efficiency of the drier was determined by weighing the steam condensate from the drum and relating it to the water evaporated from the mash.

RESULTS AND DISCUSSION

Method of Application of Feed

Compared with double-drum. The method of application of mash to a single-drum flour-type drier is unique and offers some advantages not obtainable with double-drum driers. Mashed potato is fed to a double drum by placing it on the hot drum surfaces at, and immediately above the point where the drums come together. As the drums rotate the sheet separates into two parts, each drum carrying a relatively porous, nonuniform layer. When high-solids content potatoes are used, the sheet from a double-drum is "lacy", and dilution of the mash to about 20% solids is required to produce a sheet of satisfactory density.

On the single-drum drier, a number of "spreader" rolls, spaced around the periphery of the heated drying drum, as shown in Figure 3, are used to apply the mash. Their peripheral speed is the same as that of the drying drum. They are not heated. In preliminary tests, the clearance (from ⅛ to ½ inch) between these rolls and the drum did not appear to be critical as regards the amount of feed picked up by the drum. In the tests discussed here, the clearance was ⅛ to ¼ inch. To feed the drier, mash is placed in a trough above the drum, ahead of the first spreader roll. This roll picks up a layer as thick as the clearance between it and the drum. Each succeeding spreader roll is fed either by applying fresh mash to it or by transferring mash from the preceding roll. A thin film of mash adheres to the drum as it passes under the first roll, and the succeeding rolls apply more mash to fill in the interstices left by the preceding roll.

Effect on sheet density. The successive applications of mash to an already partially dried sheet on the single-drum drier produce a denser and slightly thicker sheet. It is also more uniform in cross-section than a sheet from the double-drum drier, as shown in Figure 5. The density of the single-drum sheet, expressed as pounds of solids per 100 square feet of sheet, increases as the number of spreader rolls fed is increased. Figure 6 shows sheet density versus number of spreader rolls used, with a drum speed of 1.88 r.p.m. and mash of 18.5% solids content. The great improvement in density obtainable from the single-drum drier with 4 spreader rolls over that from a double-drum unit fed as described earlier is apparent from the location of the double-drum point on Figure 6.

Solids Content of Feed

Producers of potato flakes will process potatoes of different solids content, depending on potato variety, growing area, and growing conditions. It is, therefore, important to show how the solids content of the feed affects the amount of mash picked up on the drier drum, since the pickup at a given drum speed controls the evaporative load on the drier and the rate of production, density, and moisture content of the product. In all experiments, 4 spreader rolls were used to feed the drier.

Effect on mash pickup by the drum. If the drum picked up the same weight of feed regardless of solids content, the evaporative load on the drier would decrease as the solids content increased. Experiments

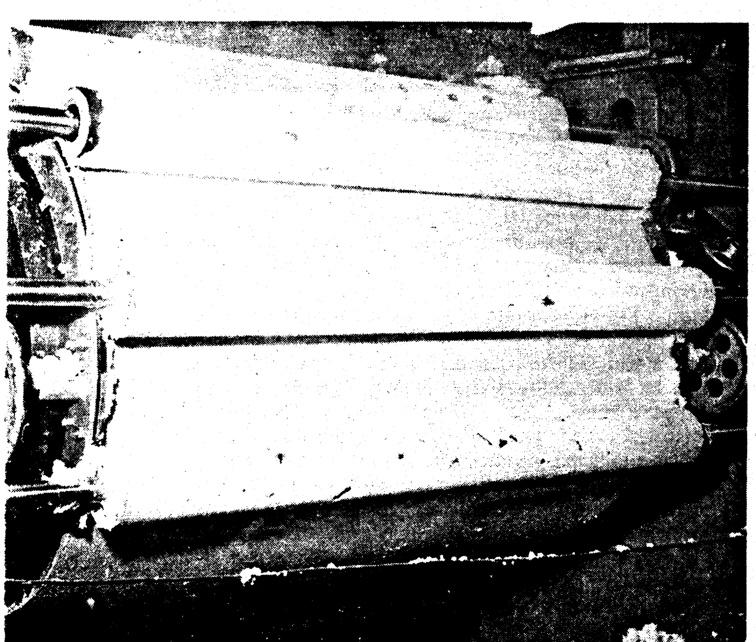

Figure 3. Application of mash to single-drum drier.

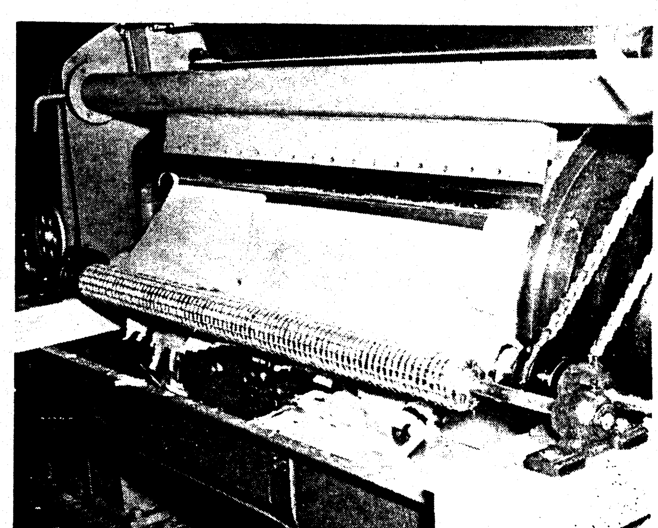

Figure 4. Product side of drier. Removing and breaking sheet.

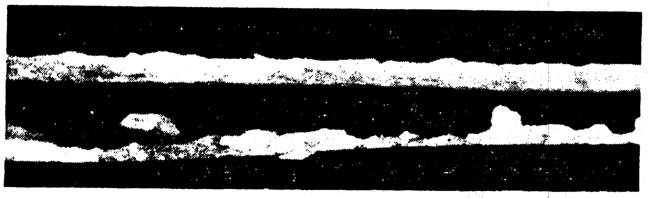

Figure 5. Photomicrographs of cross-section of sheets from single and double drum driers.
Top: Single drum; bottom: Double drum.

show, however, that it picks up more mash per unit area as the solids content increases, so much more that the amount of water picked up, as well as the amount of solids, is greater with high-solids potatoes. In Figure 7, pickup on the drum (pounds per hour per square foot of drum surface) is plotted against drum speed. Curves are shown for mash of 18.5, 20, and 21.5% solids content, and indicate the increase in pickup of mash (and water and solids contained in it) at any given drum speed, as solids content increases.

Effect on production rate. As would be predicted from the solids pickup rate shown in Figure 7, production rates increase with increasing drum speed and with increasing solids content of the feed. This is shown in Figure 8. From Figures 7 and 8 alone, it would appear that the drum should be run at high speed to take advantage of the more rapid pickup of mash, greater production, and higher evaporative rate. The physical form of the product and its moisture content, however, must be considered.

Effect on sheet density. An important attribute of the drum-drier product is density, because this affects packaging costs. Since sheet thickness is nearly constant, density can be expressed as pounds of solids per 100 square feet of sheet produced. In Figure 9, sheet density is plotted against drum speed. Curves are given for mash of 18.5, 20, and 21.5% solids content. For each solids content, the sheet density increases as the speed of the drum is reduced. The increase is most rapid at speeds of 2 r.p.m. and lower. At any given drum speed, the density increases with the solids content. Sheet density will, if flake size is constant, control package size and influence packaging cost. Since packaging costs are comparatively high, a gain in production rate at high drum speed (Figure 8) may be offset by increased packaging cost through low density (Figure 9).

Effect on moisture content of product. Figure 10 shows the relation between moisture content of the product and drum speed for mash of 18.5, 20, and 21.5% solids content. These data show that at a given drum speed the moisture content of the product increases as the solids content of the feed increases. It is indicated that for the range of feed solids content investigated, minimum moisture levels in the product are obtained at about 2 r.p.m. As drum speed is increased above 2 r.p.m., product moisture content increases because of the decreasing drying time. As drum speed is reduced below about 2 r.p.m., product moisture content increases again, probably because of the rapidly increasing resistance to diffusion due to increasing sheet density. The range of drum speed which will produce a flake of 5% moisture content or less, becomes narrower as the feed solids content increases. The range is about 1.8 to 2.3 r.p.m. for the highest solids content feed tested. The moistures shown in Figure 10 were obtained when the drier drum was heated with steam at 70 to 80 p.s.i.g. With the lower-solids content potatoes at higher drum speeds, steam pressure can be raised to 100 p.s.i.g. to obtain a lower moisture content in the product. With high-solids content potatoes, particularly at low drum speeds, increasing the steam pressure does not reduce moisture content. Under these conditions

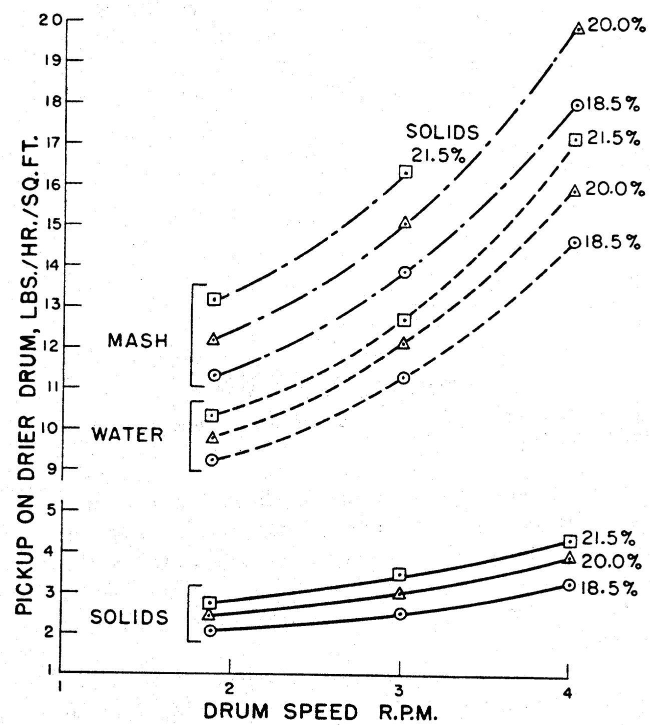

Figure 7. Effect of drum speed and solids content of feed on pickup by drum.

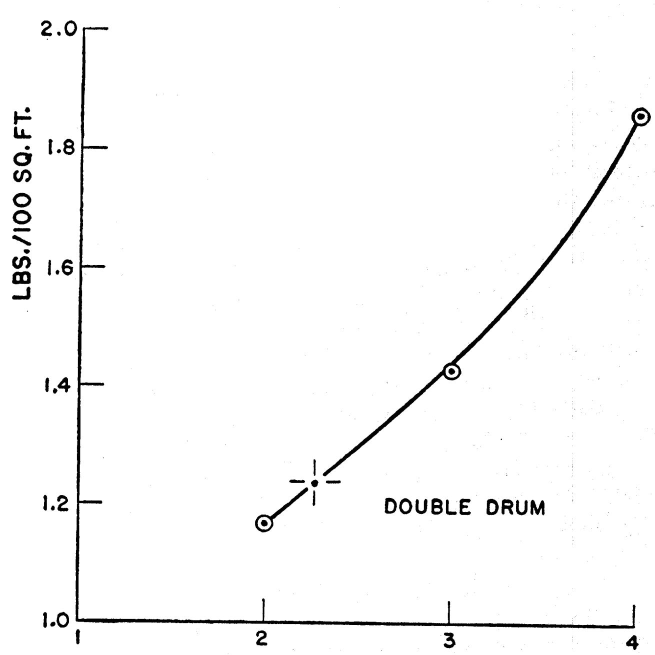

Figure 6. Effect of number of spreader rolls on sheet density.

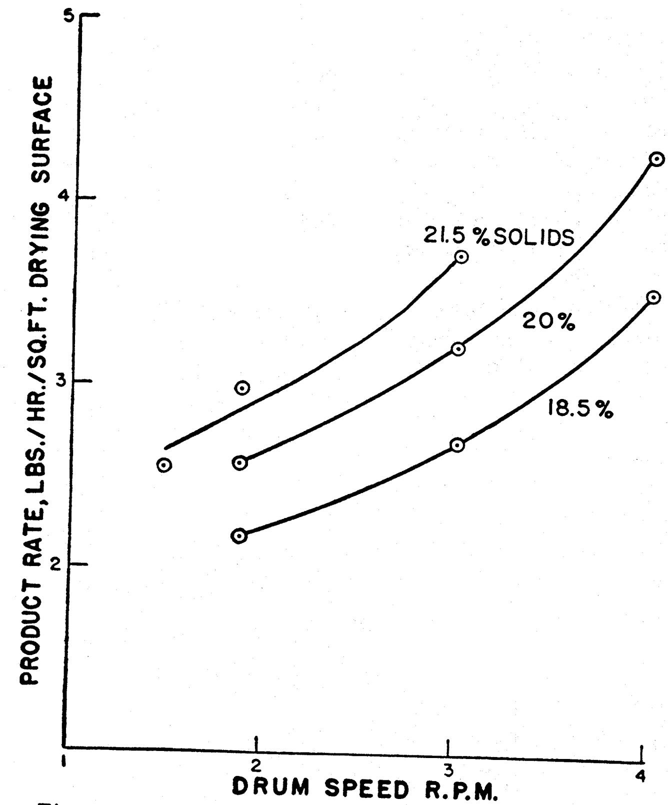

Figure 8. Effect of drum speed and solids content of feed on production rate.

a sheet of high density is produced, through which moisture diffuses slowly. The surface of the sheet in contact with the drum becomes over dried, while the average moisture content is still high, and the heavy sheet falls away from the drum before reaching the doctor knife.

One of the unusual features of the potato flake process is that a product of low moisture content can be obtained in a single drying step of 30 seconds or less. At low moisture content, nonenzymatic browning is greatly retarded, and the development of oxidative off-flavors can be retarded in potato flakes by the incorporation of an antioxidant in the mash before drying. It has been shown to be practical to produce flakes of 4 to 5% moisture content without flavor damage. In view of the advantages afforded by low moisture content, an upper limit of 5% moisture has been set for the production of samples made in the pilot plant for evaluation. Since this moisture content can be obtained at operating conditions which result in reasonable cost *(3)*, it is recommended that 5% moisture be set as a maximum in commercial production.

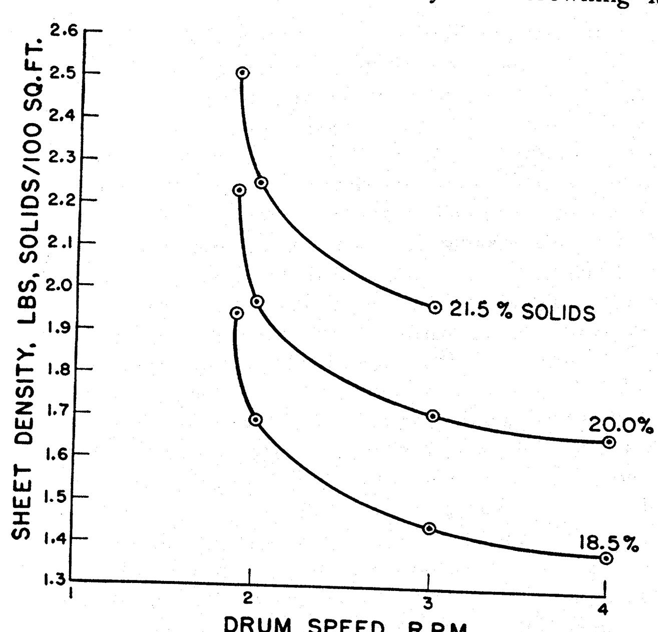

Figure 9. Effect of drum speed and solids content on feed on sheet density.

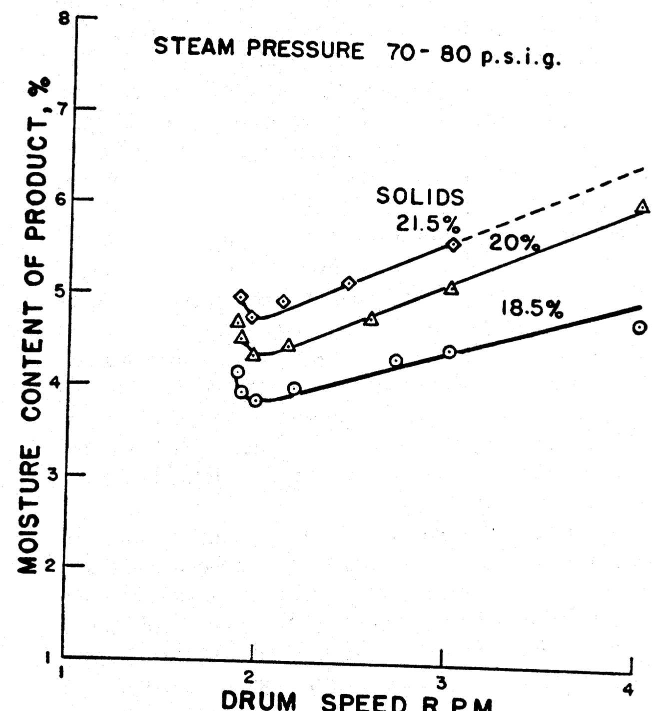

Figure 10. Effect of drum speed and solids content of feed on moisture content of product.

SUMMARY

This study was made to determine the effects of operating variables and of feed solids content on the production rate and physical characteristics of potato flakes made on a single-drum drier. The results show that in dehydrating mash of solids content in the range of 18.5 to 21.5%, the practical maximum sheet density is obtained at a drum speed just under 2 r.p.m. Minimum moisture in the product is obtained also at a drum speed of about 2 r.p.m., and the range of drum speed which will produce a flake of 5% moisture content or less becomes narrower as the feed solids content increases. With the highest solids content feed tested, this speed range is about 1.8 to 2.3 r.p.m. It is doubtful that the same absolute values will apply to a commercial drier of 4 to 4½ feet diameter. It is probable, however, that the same basic principles will apply.

LITERATURE CITED

1. Cording, James, Jr., Willard, Miles J., Jr., Eskew, Roderick K., and Edwards, Paul W. Potato flakes. A new form of dehydrated mashed potatoes. I. Pilot-plant process using double drum drier. U. S. Dept. Agr., Agr. Research Service *Circ. ARS-73-2;* 5 pp. (1954).

2. Cording, J., Jr., Willard, M. J., Eskew, R. K., Edwards, P. W., and Sullivan, J. F. Potato flakes. A new form of dehydrated mashed potatoes. II. Some factors influencing texture. U. S. Dept. Agr., Agr. Research Service *Circ. ARS-73-9;* 8 pp. (1955).

3. Eskew, Roderick K., Redfield, Clifford S., Cording, James, Jr., Willard, Miles J., Jr., Claffey, Joseph B., Edwards, Paul W., and Sullivan, John F. Potato flakes. A new form of dehydrated mashed potatoes. III. Estimated commercial cost. U. S. Dept. Agr., Agr. Research Service *Circ. ARS-73-12;* 15 pp. (1956).

4. Gemmill, Arthur V. Mashed potato flakes by low-cost process. (Staff Articles). *Food Eng.,* **28** (6) 82-84, 87 (1956).

5. Willard, Miles J., Jr., Cording, James, Jr., Eskew, R. K., Edwards, P. W., and Sullivan, John F. Potato flakes. A new form of dehydrated mashed potatoes. Review of pilot plant process. *Am. Potato J.,* **33** (1) 28-31 (1956).