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EXPLOSION PUFFING DEHYDRATION OF FRUITS AND VEGETABLES: PROGRESS ON A CONTINUOUS SYSTEM

One of our developments that we hope will contribute significantly to "technology for convenience" is the explosion-puffing dehydration process. This process makes dehydrated vegetable and fruit pieces which rehydrate rapidly. For example, 3/8 in. carrot cubes are ready to eat after only five minutes simmering, as compared to the same size conventionally air dried pieces, which require about 45 minutes to cook.

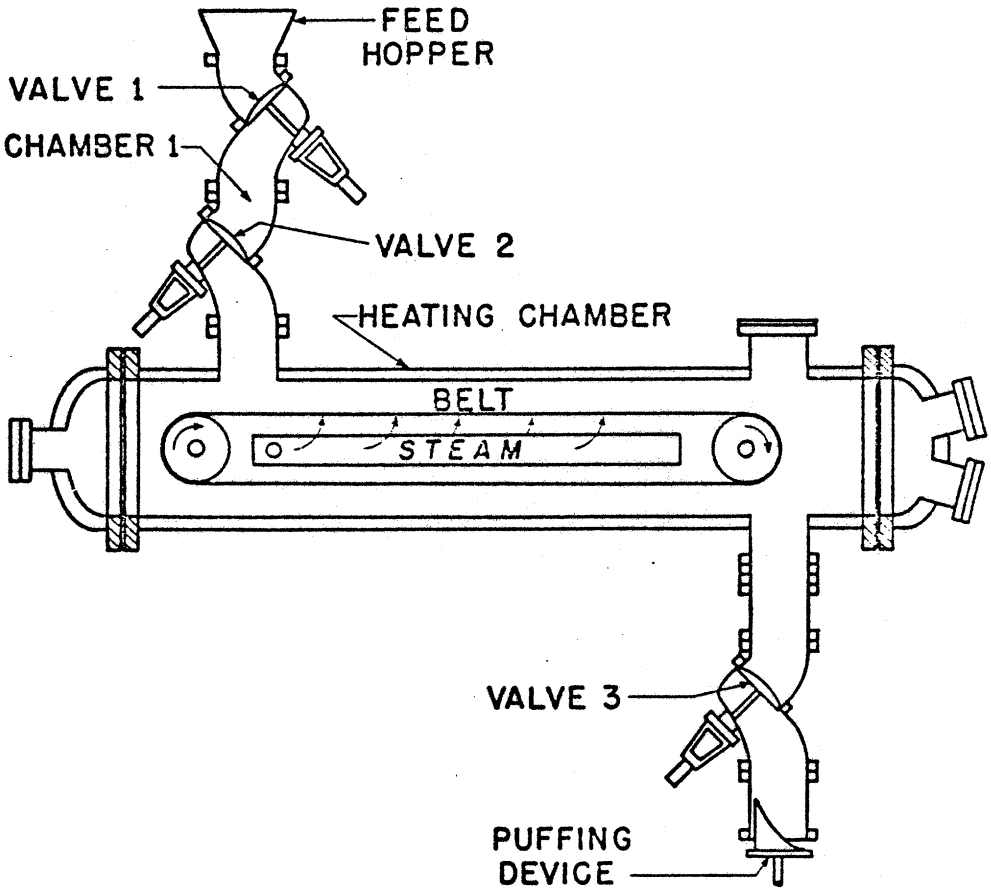
For explosion-puffing, food pieces are conventionally dried to 18-35% moisture, depending on the commodity. These pieces are placed into a puffing gun-a cylindrical pressure vessel with a hinged lid-and are heated therein by flowing superheated steam under pressure until their remaining water is heated above its atmospheric boiling point. The lid is then opened instantaneously. The rapid drop in pressure then causes some of the water to flash into steam as the pieces are shot from the gun. The escaping steam imparts a porous structure to the piece which permits rapid final drying and subsequent rapid rehydration. We designed our own gun since no other equipment was available on the market to satisfy our requirements.

We have also successfully batch puffed white potatoes, sweet potatoes, beets, rutabagas, red and green peppers, celery, apple segments, and whole blueberries. White potato and sweet potato pieces as large as 3/4 in. x 1/2 in. x 1/2 in. have been made. Cost analyses on the batch process projected to commercial scale for carrots, white potatoes, and apple slices show potential profitability.

Industry evaluation of these products have been extremely favorable. From discussions with industry representatives, and because of the obvious labor savings a continuous process would achieve, it appears unlikely that the batch process will be adopted on a large scale as long as the possibility exists that it can be made continuous.

Two functions are carried out in the batch gun--heating and puffing. Early in our investigations, when we realized the limitations of size and output of the batch gun, we conceived the idea of separating the operations of heating and puffing, that is, a continuous explosion puffing system (U. S. Patent 3,392,660, July 1968). This system was designed at the Eastern Regional Research Center, has been installed, and experiments are in progress to discover needed mechanical improvements and to optimize the continuous process for the various products.

THE NEW SYSTEM



Although short runs have already been made, producing well-puffed carrot, white potato, and apple pieces, we are still in the equipment development stage.

The accompanying figure shows a schematic diagram of the new system. It comprises two inlet valves, a steam-jacketed heating chamber, an outlet valve, and a puffing device. Opening and closing of the valves, pressurizing of the chambers, and operation of the puffer are controlled in the proper sequence from a master cam shaft which operates pneumatic pistons on the valve stems. Referring to this figure, partially-dried pieces are conveyed continuously at a controlled rate to the feed hopper. Valve 1 opens to admit feed to chamber 1 and then closes. Chamber 1 is then brought to the same pressure as that of the heating chamber by admitting superheated steam or compressed air. Valve 2 opens dropping feed onto the belt of the heating chamber and then closes. Chamber 1 is bled to atmospheric pressure. The feeding cycle keeps repeating as the pieces are conveyed through the heating chamber at a controlled rate. This rate will be such as to provide an estimated residence time in the chamber of one minute or less. The heating chamber is held at a predetermined pressure by flowing superheated steam, and steam in the jacket prevents desuperheating and condensation of process steam on the inner walls. Heated pieces fall from the belt to the top of valve 3, which opens at intervals to the puffing device which is brought immediately before to chamber pressure. Valve 3 then closes and the puffing device is opened mechanically, instantly discharging the pieces and puffing them.

After the equipment has been perfected and experiments to optimize the process have been completed, including capacity tests, costs will be calculated and sufficient material for market testing can be made available.

In addition to the labor-savings that should result from the continuous system, there is a good chance that improved product quality and uniformity will result, that products not successfully made in the batch gun can be made, and that the process could be more attractive to industry.

Bibliography

(1) Eisenhardt, N. H., Eskew, R. K., Cording, J., Jr., Talley, F. B., and Huhtanen, C. N. 1967. Dehydrated explosion puffed blueberries. U.S. Agricultural Research Service, ARS 73-54.

(2) Eisenhardt, N. H., Cording, J., Jr., Eskew, R. K., and Heiland, W. K. 1968. Dehydrated explosion-puffed apples. U. S. Agricultural Research Service, ARS 73-57.

(3) Eisenhardt, N. H., Calhoun, M. J., Talley, F. B., and DellaMonica, E. S. 1969. Storage properties of dehydrated applesauce made from explosion puffed pieces. Food Technol. 23:159-162.

(4) Strolle, E. O., Cording, J., Jr., McDowell, P. E., and Eskew, R. K. 1970. Effect of sucrose on crispness of explosion-puffed apple pieces exposed to high humidities. J. Food Sci. 35:338-342.

(5) Stabile, R. L., Turkot, V. A., Eisenhardt, N. H., and Cording, J., Jr. 1971. Explosion-puffed apples are commercially feasible. Food Product Development 4:80, 83, 86-88.

(6) Turkot, V. A., Eskew, R. K., Sullivan, J. F., Cording, J., Jr., and Heiland, W. K. 1965. Explosion puffed dehydrated carrots. III. Estimated cost of commercial production using shortened cycle. U. S. Agricultural Research Service, ARS 73-49.

(7) Turkot, V. A., Sullivan, J. F., Cording, J., Jr., Eskew, R. K., and Heiland, W. K. 1967. Explosion puffed dehydrated potatoes. III. Estimated cost of commercial production using shortened cycle. U. S. Agricultural Research Service, ARS 73-55.

(8) Cording, J., Jr., and Sullivan, J. F. 1973. Retarding browning in explosion-puffed potatoes. Food Eng. 45:10:95-97.

(9) Sullivan, J. F., Konstance, R. P., Calhoun, M. J., Talley, F. B., Cording, J., Jr., and Panasiuk, O. 1974. Flavor and storage stability of explosion-puffed potatoes: Non-enzymatic browning. J. Food Sci. 39:58-60.

(10) Heiland, W. K. and Eskew, R. K. 1965. A new gun for explosive puffing of fruits and vegetables. U. S. Agricultural Research Service, ARS 73-47.

(11) U. S. Patent 3,392,660, July 1968. Food Processing Apparatus. J. Cording, Jr.

(12) Sullivan, J. F., Cording, J., Jr., and Eskew, R. K. 1963. Quick-cooking dehydrated sweet potatoes. Food Eng. 35:59-60.

(13) Sullivan, J. F. and Cording, J., Jr. 1969. Explosion-puffed celery rehydrates efficiently. Food Eng. 41:90-93.