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Puff drying: continuous, economical, versatile

Larger pieces of fruits and vegetables retain their color, flavor, and nutrition when explosion puffing is interposed between drying steps. The products have excellent rehydration and cooking properties.

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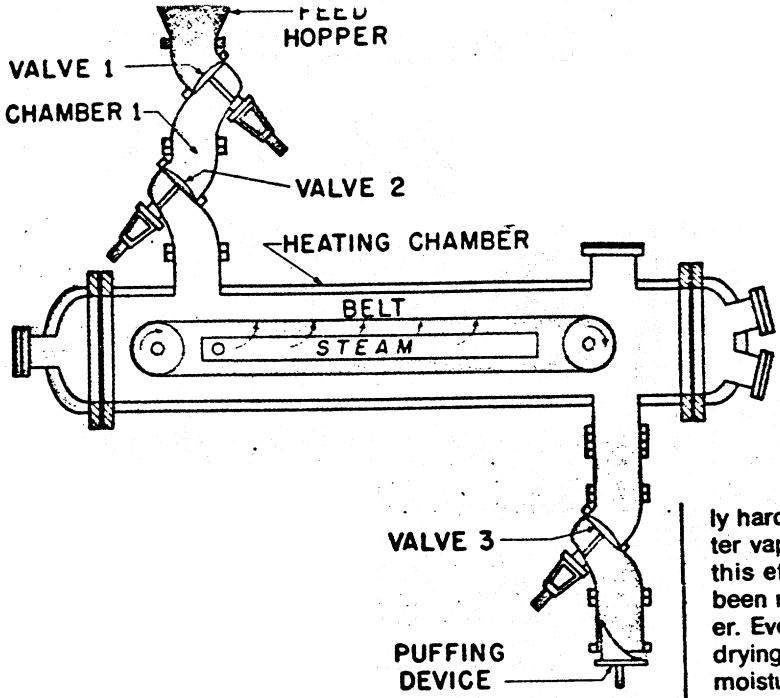
CEPS is the acronym for Continuous Explosion Puffing System. Designed by USDA engineers at the Eastern Regional Research Center (ERRC), it is capable of accelerating the drying of certain fruits and vegetables. In addition to doubling conventional drying capacity, CEPS intervention results in a remarkable energy saving, better than 40%, according to comparative tests on drying sliced apples at ERRC. Another CEPS plus in this energy conserving area is potential economy in transportation fuels, refrigeration energy, and packaging materials. CEPS fruits and vegetables may replace canned and frozen counterparts in many ways. CEPS works well on more than a dozen different firm-fleshed fruits and vegetables, including many of the highest volume sellers. The new dried products have been evaluated during several years of investigation.

Operating details

In the operation of CEPS, the valve at the top of the feed chamber opens to receive a measured quantity of partially dried fruit or vegetable pieces, then closes and the chamber is pressurized. The valve at the bottom of the feed chamber opens and the pieces are spread onto a moving belt in the heating chamber, which is filled with superheated steam. The pieces drop off the belt into the discharge chamber after about 1 minute of travel. A third valve closes, sealing them in the discharge chamber. The discharge piston abruptly opens the bottom of the chamber, flashing some water into steam, and the pieces are explosively blown out into a collector. The puffed product finishes drying in a hot air dryer, and the CEPS cycle restarts. The pilot unit processes 1,000 lb/hr of ⅜" potato dice at 25% moisture. This is enough to puff 3 tons of raw potatoes per hour.

CEPS is an intermediate processing adjunct to conventional hot air drying. Only the puffing unit need be added to an existing dehydrator line. Drying is interrupted at the desired moisture level, depending on the size and texture of the pieces to be treated. An advantage to existing plants, then, is the low installation cost for the processing of superior quality dried fruits and vegetables. A CEPS unit like the one described above is estimated to cost approximately $150,000 with instrumentation and controls. The operating cost for the puffing step is recovered by heat energy savings in the main dehydrator. The partially dried, puffed pieces desiccate to the desired 5% level in a fraction of the time needed for untreated ones. Shortening of drying time saves more than enough energy to run the CEPS step and greatly increases dryer throughput capacity.

Many types of fruit and vegetables can be treated. Turnips, beets, sweet potatoes, peppers, celery and onions



Schematic diagram of the ERRC Continuous Explosion Puffing System, showing its major components: a volumetrically controlled feed chamber, a heating chamber with a moving belt, and a discharge chamber that may be instantly opened to the atmosphere by a puffing device.

are CEPS-processible, as are potatoes and carrots. Apples can be processed in chunks, slices, or sections for pies and desserts, and they make a great dry snack. Ground CEPS-processed applies are instant applesauce. Whole blueberries can be puffed and dried, and other firm fleshed fruits are likely candidates. Also, larger quick-cooking pieces, including ¾" dice and ¼" slices, are not attainable without puff drying.

Taste panel results

Many taste panel evaluations have been made on reconstituted samples of dried fruits and vegetables puffed in the CEPS unit. CEPS-dried foods rate close to their freeze dried counterparts and better than conventional dehydrated items. Tests for specific uses have indicated that CEPS-dried items are suitable as commercial recipe ingredients and for pies and other baking uses. They have been considered acceptable as meal side dishes by representatives of the Armed Forces. Processors might need to educate the public to use CEPS products instead of canned or frozen ones. This shouldn't be too difficult if the energy economies are passed along to the consumer, since the quality is acceptable.

CEPS pieces, precooked and sterilized by the superheated steam in the heating chamber, may be useful as aseptically packaged intermediate moisture fruit and vegetable ingredients in compound prepared foods. This would save the energy cost of drying to ambient-stable moisture.

Finish drying with CEPS is economical, compared to conventional processing, and CEPS pieces have the intrinsic values of fast cooking and the ability to retain minerals and solubles, together with superior appearance, flavor, and texture. Dried, they require only a moisture barrier film (plus, in some cases, an antioxidant) to retain high quality with acceptably long shelf life at ambient temperature. CEPS foods are light-weight and will keep without refrigeration for a year or more.

Conventional dehydration of fruits and vegetables is accomplished principally in a hot air dryer that has a moving belt passing through a drying tunnel. Heated air is circulated through and around the belt, evaporating water from the surface of the food chunks. As drying continues, the surface of the piece becomes progressively harder, increasing its resistance to the passage of water vapor. The larger the piece, the more pronounced is this effect. Conventionally dehydrated materials have been restricted in size to ⅜" cubes, and often are smaller. Even under optimum conditions, conventional hot air drying yields products that are far from ideal. The final moisture must be around 5% to ensure against spoilage in storage, and by the time this moisture level is reached, the surface is virtually "case hardened." Cubes have collapsed and become concave-sided, with a discolored appearance. Some require ¾ hour in boiling water to be reconstituted (longer for large cubes).

An alternative method for the production of dehydrated fruits and vegetables—freeze drying—evolved about thirty years ago. However, water removal by this process is energy intensive, and is becoming increasingly costly by the day as fuel prices rise.

Alternative to freeze drying

The Engineering and Development Laboratory at ERRC sought an alternative to freeze drying. The desirable characteristics of freeze dried products are due to channels left in the flesh that allow fast entry of water during reconstitution. The engineers reasoned that they could find another way to accomplish channeling. Partially dried pieces are subjected to moderate steam pressure to superheat the water in them. When the steam pressure is released instantly, the water flashes to steam, explosively issuing from inside each piece, seeking and opening up channels in the flesh. This creates the desired porous structure. Fruits and vegetables air-dry to finished moisture faster and rehydrate in boiling water with extreme rapidity—in minutes. This processing concept is named 'explosion puffing' to describe the steam release, even though the pieces do not puff up materially in size as grain does in the manufacture of puffed cereals.

The puffed cereal analogy led to the design of the first unit, which was similar to the type used in cereal processing: a rotating cylinder with a pressure-tight hinged lid, capable of instant opening. The puffing gun stirred excitement among dehydrator operators in the 1960's, and a number of units were built commercially for experimental use. Some production continues in similar or modified equipment, but the process has not assumed high-output proportions. This is because of the intermittent, labor-intensive, batch production requirement of "load and fire." Experimentation showed that separation of the heating and puffing steps resulted in better control and quality. This concept went into the design of the *continuous* explosion puffing system, which is now fully operable and on the verge of commercialization by several interested firms. FE