Explosion-Puffed Celery Rehydrates Efficiently

It resembles the original product in color, flavor and texture. Therefore the puffed celery can be used in soup mixes or as a snack

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EXPLOSION PUFFED and dried celery reconstitutes rapidly to a piece of good color, flavor and texture. The celery slices have a porous internal structure, which makes them ideal for dehydrated soup mixes. In the dry state, they are crisp and can be used as a snack.

Explosive-puffing was developed at USDA's Eastern Utilization Research and Development Div. (1). It has been applied successfully to white potatoes (3, 4, 13), carrots (2, 4, 9, 12), beets (2), sweet potatoes (10), blueberries (5, 6), and apples (5, 7). A shortened cycle (6, 8, 11, 12,

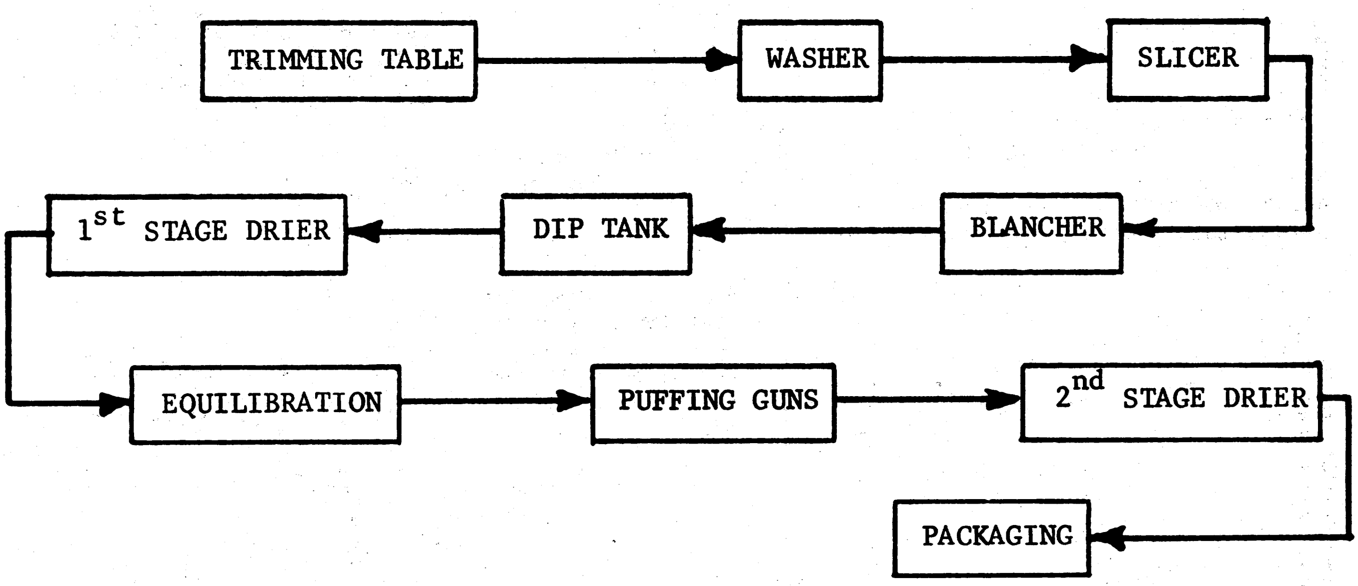


FIG. 1. FLOW SHEET shows processing steps for preparing dehydrated explosion-puffed celery.

13), developed at our facility was used in our research on celery. It employs superheated steam for puffing which reduces processing time and thereby, the possibility of heat damage. It also reduces the cost of the process considerably.

Research Findings

In our investigation, we observed a difference between rehydrated samples of California and Florida celery. Tasters found rehydrated Florida celery more tough, possibly because it was incompletely puffed. Tests were run to check the amount of puff and the rehydration ratios of celery from both growing areas, as affected by charge size.

Charge sizes of 5-, 10-, 15-, and 20-lb of California and Florida Pascal celery were puffed and dried. All charges were successfully puffed if they were within 35-40% moisture and puffed at 35 psi.

Porosities and rehydration ratios of similar charge sizes were compared. Rehydration ratio, i.e., the ratio of rehydrated weight to dry weight, was determined by simmering 50g of the dry product in 1 lb of water for 2, 3, 5, and 8 min, draining and weighing. Total porosity was determined with a Beckman Model 930 Air Comparison Pycnometer (16).

Assuming greater porosity means more effective puffing, indications were that smaller charges were more puffed than larger ones (Fig. 2). Both Florida and California celery were puffed. Little

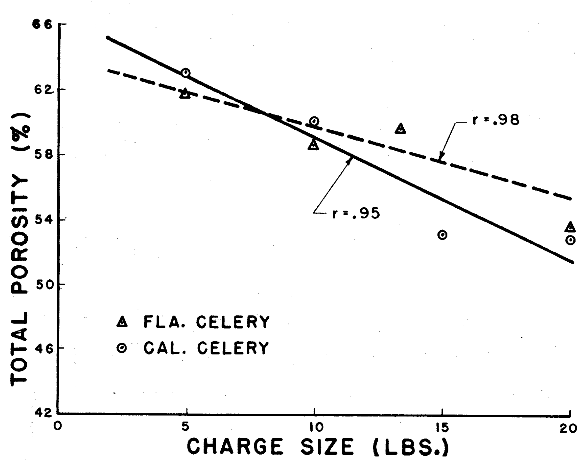


FIG. 2. POROSITY of both California and Florida celery is reduced as the gun charge is increased.

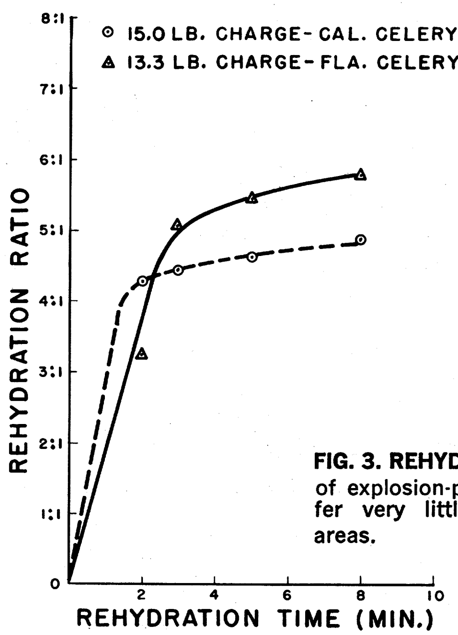


FIG. 3. REHYDRATION RATIOS of explosion-puffed celery differ very little with growing areas.

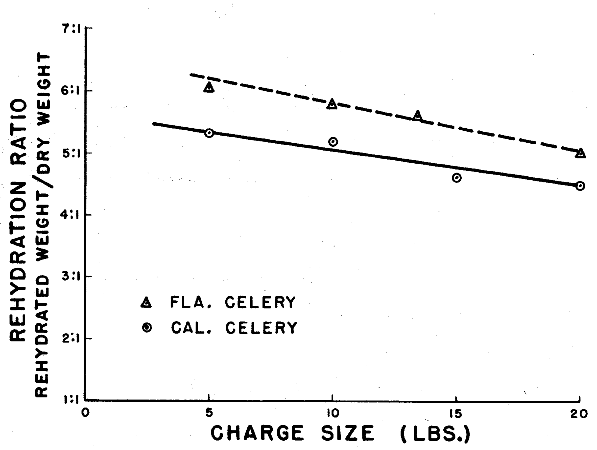
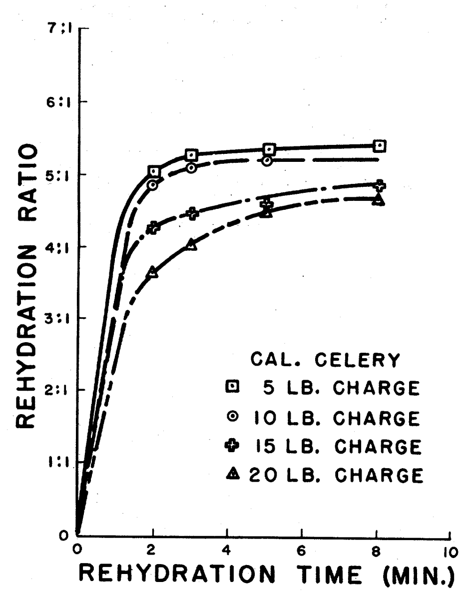


FIG. 4. REHYDRATION RATIOS of both California and Florida celery decrease with increasing gun charge.

FIG. 5. SMALLER CHARGES of celery are puffed to a greater extent, as shown by their relative rehydration ratios.



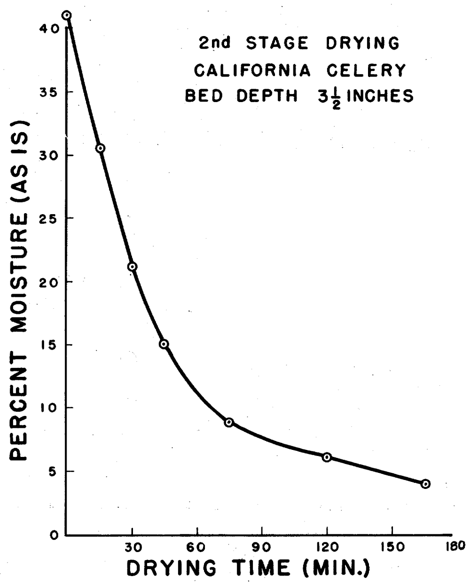


FIG. 6. RAPID FINAL DRYING of explosive-puffed celery is due to the increased porosity of the product.

. . . PUFFED CELERY (CONTINUED)

difference was found in rehydration ratios due to growing area with charges of approximately the same size (Fig. 3).

Fig. 4 shows that increasing the charge size reduces the rehydration ratio. It also shows little difference between Florida and California celery. Assuming higher rehydration ratios indicate more effective puffing, Figs. 4 and 5 indicate smaller charges to be more puffed.

Since little differences were shown by these objective tests and considerable difference in tenderness was found by the taste panel, shear tests were employed to help explain these differences. For this evaluation, we used a Kramer Shear Press (Model SP-12 Imp).

Twenty grams of fresh celery were cut from the outer stalk and placed one stalk high, concave downward in the test cell. California celery sheared at 310 lb, while the Florida celery sheared at 483 lb. Thus it was established that the raw materials were different in toughness (see table).

For these tests, 30-g samples of the 5- and 15- (Florida 13.3) lb charges were rehydrated by simmering 5 min in boiling water. Each sample was individually placed concave downward in the test cell. Conventionally dried (unpuffed) celery had to be simmered 15 min to soften enough so that the shear force could be observed on scale.

As indicated in the accompanying table, Florida celery was tougher in all cases. As charge size was increased, less puffing was obtained and this seems to be reflected in the increase in shear force, i.e., toughness. The 20-lb charge from both growing areas, was poorly puffed due to the large charge size. However, the 20-lb charge of California celery, when reconstituted, did make an acceptable product as judged by taste panel.

For product evaluation, 40g of product were boiled about 6 min in a cup of water to restore the slices to their original shape. They had an appealing green color and characteristic flavor of freshly cooked celery.

Processing Technique

As shown in Fig. 1, production of explosion-puffed celery entails raw material preparation, initial drying, equilibration, explosive-puffing, and final drying.

Raw material preparation. Roots and leaves were removed from the celery and stalks were separated from the hearts. The latter can be sold as a premium product, but cannot be processed because they brown during drying.

Next, stalks were washed and cut into 3/16-in. slices. Processed slices of this thickness return to their original shape on rehydration, whereas ½-in. slices do not and have a limp appearance.

Celery slices were blanched for 6 min in a boiling ½% sodium bicarbonate solution. This temperature destroys peroxidase (14), while the bicarbonate controls pH to preserve the green color. After blanching, slices were dipped for ½ min in a ½% sodium bisulfite solution. In vegetable dehydration, sulfur dioxide retards the browning reaction, increases the retention of ascorbic acid, and exercises a useful antimicrobial effect during the initial drying stage. The sulfur dioxide was controlled to give 500 to 1,000 ppm in the dried celery.

Initial drying. Partial dehydration of celery reduces its wet-basis moisture content to a suitable level for puffing (35-40%). Moisture content was determined on the puffed and unpuffed dice by loss of weight after 16 hr in a vacuum oven at 70C.

Commercially, initial drying would probably be done in a through-circulation belt dryer. Pilot-plant drying was done in a cabinet-type tray dryer simulating commercial practice. Perforated stainless steel trays were individually loaded to a bed depth of 4 in., corresponding to 12 lb per sq ft. Air was passed downward through the bed

SHEAR FORCES REQUIRED FOR CELERY SAMPLES, LB			
	Charge Weight, Lb		
	5	15	Unpuffed
California	386	528	490
Florida	655	840	1005

at 175F dry bulb and 100-110F wet bulb at about 200 fpm. When about half the water was evaporated, as determined by weight loss, the dry-bulb temperature was reduced to 150F and the directon of air flow changed. Moisture content of the pieces was reduced from 95% to 36% in 3 hr. A final bed depth of ¾-in. was obtained from the original 4-in. bed.

Equilibration. Moisture distribution within the celery slices is not uniform at the end of partial drying. Moreover, puffing immediately after drying would produce a non-uniform product. Therefore, an equilibration period is recommended. The slices were held in plastic bags inside a closed container for 18-24 hr. Mold developed during equilibration at 73F, so the celery slices were equilibrated at 38F.

Explosive-puffing. As celery slices discharge from the puffing gun, flashing of superheated water from within the slices gives them a porous internal structure. Continuous flow of superheated steam through the gun provides rapid superheat and minimizes heat exposure. The puffing gun used in pilot plant studies is described by Heiland and Eskew (8).

Operating procedure for the gun, in this case, was the same as described by Turkot et al (12) for carrots, except that the gun-surface temperature was held at 300F.

Puffed celery slices were discharged from the gun at somewhat higher moisture than that of the original charge. Condensation of superheated steam on the relatively cold charges (room temperature) increased the moisture of the slices 4-5%.

Final drying. The puffed slices required further drying to a moisture of 4% or less (15) to ensure storage stability. In pilot plant studies, the same tray dryers that were used in the initial drying cycle were used for final drying. However we used smaller trays.

Trays were loaded to a bed depth of 3½ in., corresponding to 5½ lb per sq ft. Air was passed downward through the bed at 130F dry bulb, 95-100F wet bulb at about 200 fpm. A curve of the final drying is shown in Fig. 6.

Usually, final dehydration of vegetable pieces requires many hours (3) and bin-drying is resorted to in order to reach low-moisture content. As shown in Fig. 6, the time for final drying of explosion-puffed celery pieces was short, 2¾ hr. This rapid drying is due to the porous structure imparted during puffing.

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