ACKNOWLEDGEMENTS

The author is indebted to the Can Manufactures Institute and National Canners Association for financial support. Appreciation is expressed to Mr. D. G. A. Kelbert, Gulf Coast Station; Dr. P. H. Everett, South Florida Field Laboratory; Mr. N. C. Hayslip, Indian River Field Laboratory; and Dr. P. G. Orth, Subtropial Station, for assistance in procuring the fruit. Appreciation is also extended K. Markham Brothers, Princeton, and W. G. Enns, Continental Can Co.; R. Fairbrother, American Can Co.; and H. Hannan, Crown Cork and Seal Co., for valuable assistance in processing the Homestead area fruit.

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THE EFFECT OF SOME PREDRYING TREATMENTS ON THE REHYDRATION OF CELERY

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ABSTRACT

The effect of predrying treatment on rehydration varies somewhat, depending on the method of rehydration. The best rehydration was obtained when dried celery was shaken in cold water, regardless of pre-drying treatment. Rehydration by boiling was usually better than by soaking in cold water. All of the pre-drying treatments studied inhibited rehydration by soaking in cold water.

Blanching, freezing, and puffing, when applied separately as the only treatment before drying, each inhibited rehydration in boiling water. Blanching and puffing, when applied separately as the only treatment before drying, inhibited rehydration by the cold shake method.

Freezing before drying markedly increased rehydration by cold shaking. It would be the preferred treatment when speed of rehydration was not essential because of the simplicity of the process, high yield of dried product, and better flavor retention.

The best rehydration in boiling water was with celery that had been blanched, frozen, pressed and puffed before drying. Celery prepared in this way also rehydrated well by the cold shake method.

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References to brand names do not indicate endorsement.

INTRODUCTION

Studies in this Laboratory on processes for preparing dehydrated celery with improved rehydrating characteristics and better texture have been reported (1, 2). A predrying treatment that involved blanching, freezing and thawing, and explosion puffing was found necessary for best rehydration in boiling water. This paper describes further studies on improving the rehydrating characteristics of dried celery.

The poor rehydration of some of the individual pieces in dried celery prepared by the improved process detracted from its appearance. Lack of uniformity in moisture content of the partially dried celery going into the puffing gun appeared responsible for the uneven rehydration. Uniform partial drying is not practical by conventional methods when individual piece size varies as much as cross-cut celery ribs. Pressing the blanched, frozen and thawed celery in a rack-and-cloth press was studied as a method for obtaining a uniform, optimum moisture content for puffing. Cold water leaching was also included as a predrying treatment.

Variations in solids content between different lots of celery and losses in soluble solids during predrying treatments have a pronounced effect on rehydration. For example, a celery that originally contained 4 percent total solids would, when dried, have to absorb half again as much water as celery that originally contained 6 percent total solids if the two samples are to achieve the same degree of restoration during rehydration. Similarly, losses in soluble solids as a result of leaching, drip, or pressing during preparation also increase the amount of water the dried celery would have to absorb to maintain a given degree of restoration during rehydration. In the studies reported here, a total solids balance was made for each sample to permit accurate appraisal of the overall effect of each predrying treatment and to permit averaging the results obtained with different lots of celery.

Materials and Methods

Selection and Preparation of Celery.—Four lots of Florida-grown Pascal-type celery were used for this study. Seven or eight crates of each lot were obtained from commercial fields during regular harvest and hauled to Winter Haven for processing. Between periods of actual preparation or processing the celery was held in 40° F storage.

Ribs were separated by cutting through the stalk butt. Leaves were removed and much of the wide bleached portion of the rib base cut off. Bleached inner ribs and hearts were discarded. The selected, trimmed ribs were washed and cross-cut into ¼-inch slices by means of an Urshell Model OV slicer. This size cut was selected because it is more difficult to rehydrate than thinner cuts used by commercial dehydrators. The thicker cuts would tend to accentuate the effect of predrying treatments on rehydration. The yield of prepared slices was about 50% of the crated celery. The cut celery of each lot was thoroughly mixed in a mortar box and divided into sub-lots of 6 kilograms each. In all subsequent processing operations care was taken to avoid mechanical loss of celery.

Predrying Treatments.—Four predrying treatments: (1) blanching, (2) freezing, (3) pressing, and (4) explosion puffing were applied to the four lots of celery. The treatments were applied singly, except pressing, and in all possible combinations within the order shown. In addition, water leaching was applied to celery that had been blanched, frozen and pressed. The leached celery was then repressed before puffing. Water leaching was also applied to one or two of the celery lots at selected steps in the pretreatment.

Blanching was accomplished by spreading the cut celery 1½ to 2 inches deep in stainless steel screen baskets and steaming for three minutes at 212° F. The celery was then cooled by submerging in running water for two minutes. It was drained two to three minutes. Cut celery was frozen in polyethylene bags by storing overnight at −5° F. It was thawed in stainless steel baskets. Juice that dripped from the celery during thawing was discarded.

Pressing was accomplished by means of a rack-and-cloth press. Pressures of 10 to 15 pounds per square inch on the cheeses were held up to 10 minutes. The press cake was broken up by hand and repressed to a moisture content suitable for puffing. About 83% moisture, when puffed, resulted in maximum rehydration. Leaching consisted of submerging the cut celery in running water for periods of three hours or overnight. Explosion puffing was applied to the partially dried or pressed celery by means of a gas-heated puffing gun previously described (2). A puffing pressure of 30 pounds was used.

Drying.—The prepared celery was dried at 160° F in a tray-type air blast dryer that has been previously described (2). To reduce mechanical losses the celery was loaded into stainless steel screen baskets provided with screen covers. The arrangement of these baskets in the dryer was such that air velocity past the celery was somewhat less than that reported in the earlier study because of space available for air to bypass the celery.

The celery was mixed and redistributed in the baskets periodically to promote more uniform drying. Celery being partially dried for puffing was removed from the dryer when the product weight indicated a moisture content suitable for puffing. The moisture content of the fully dried celery varied from 1.9 to 4.9%, but most samples were close to 2.5%.

One sub-lot of cut celery was dried by the vacuum freeze method using a Stokes Model 12-F drier. The product temperature was held below +90° F. The melted condensate was free from celery odor.

Rehydration.—Three methods of rehydration were used and all rehydrations were performed in duplicate. First, rapid rehydration was accompished by placing 5 grams dried celery in a 1500 ml beaker containing 1000 ml of rapidly boiling distilled water. Boiling was continued for 15 minutes with frequent hand stirring. The celery was allowed to steep for five minutes before being drained for two minutes on a stainless steel screen supported at an angle of about 30°. The drained celery was then weighed. The excessive water used in this method was to provide continuous free agitation of the pieces by the boiling action.

Second, the celery was soaked in cold water, a rehydration procedure recommended by commercial celery dehydrators. Five grams of celery were placed in a 600 ml beaker containing 300 ml of distilled water at 40° F and held at this temperature for 16 hours before being drained and weighed as for the boiling procedure.

The third method involved shaking the celery in cold water. This new procedure was developed when it was observed that agitation or stirring considerably increased the absorption of water during rehydration. Five gram samples of dried celery were placed in 750 ml Erlenmeyer flasks containing 300 ml distilled water at 40° F. The samples were shaken on a reciprocating laboratory shaker at 130 to 150 cpm in a 1⅜-inch travel for 16 hours in a 40° F room. The flasks were stoppered and held in an upright position. Draining and weighing were as for the boiling method.

Determination of Total Solids.—From 3 to 30 grams of celery, depending on the moisture content, were weighed into tared moisture dishes and dried under vacuum at 70° C for 20 to 24 hours. The percent total solids was calculated from the weight of the celery before and after drying. Total solids were determined on samples of raw, prepared, cut celery; on the celery just before puffing or, if not puffed, before drying; and on the dried product. The total weight of celery was determined at the same time and corrections made for material removed for samples so total solids balances could be calculated.

Calculations.—The percent loss in solids was calculated from the difference between the weight of moisture-free solids in the starting celery and in the celery placed in the puffing gun or dryer. The yield of dried celery, as percent of theoretical, was calculated from the difference between the weight of moisture-free solids in the starting celery and in the celery recovered from the dryer. The yield of rehydrated celery, as percent of the original fresh weight was calculated from the difference between the weight of the rehydrated drained celery and the weight of the raw, cut celery from which each dried sample had been prepared.

Results and Discussion

Variations in total solids among the four lots of celery used are shown in Table I, together with variety, production area, harvest date, and general observations on each lot. The range of

Table I. Celery used in predehydration treatment study

Source	Harvest date	Variety	Comments	Total solids %	Computed[1/] drying ratio
Zellwood	11/15/65	Florimart	4 doz/crate, small ribs, quite green	5.28	18.9/1
Zellwood	11/29/65	#683	2, 2 1/2, 3, 4 doz/crate, not as green as 11/15/65 lot	4.78	20.9/1
Belle Glade	1/21/66	#683	2 doz/crate color variable	3.76	26.6/1
Belle Glade	2/25/66	#213	2, 2 1/2, 3, 4, & 6 doz/crate, some hollow stems due to frost	4.06	24.6/1

[1/] Ratio of weight of raw, cut celery to weight of dried celery containing zero moisture. Computed from total solids.

solids in these lots would result in drying ratios that varied from 18.9 to 1 and 26.6 to 1, if there were no losses and drying were carried to zero moisture. The significance of these variations in solids becomes more apparent when it is recognized that it would require 140 pounds of fresh celery from the January 21 harvest which contained 3.76% soilds to make the same weight of dried product as would 100 pounds of celery from the November 15 harvest which contained 5.28% solids.

The same situation pertains when the dried celery from these two lots are rehydrated. To achieve rehydration to its original weight dried celery prepared from the January 1 harvest would have to absorb 25.6 times its weight of water. Dried celery prepared from the November 15 harvest would be completely rehydrated when it had absorbed 17.9 times its weight of water.

The effect of 14 predrying treatments on loss of soluble solids, yield of dried celery, and on rehydration are shown in Table II, together with similar data for untreated, dried celery. The values shown are the averages of values obtained on the four lots of celery listed in Table I. The treatments are listed in the order of increasing rehydration by the cold shake method.

Total Solids Balance.—Addition of the loss in soluble solids and yield values for each of the treatments in Table II shows that losses of celery pieces during manipulation were negligible. Maximum variation from 100 in the sums are −3.4 to +3.8 and the plus and minus totals are 11·3 and 16.2, respectively, for all treatments. The yield values are considered slightly more reliable than the loss in solids values because the considerable variation in moisture content of partially dried samples precluded accurate sampling. For this reason the yield values were used in calculating rehydration.

Rehydration.—Explosion puffing, when it was the only pre-drying treatment, treatment one in Table II, resulted in celery with the poorest rehydration among all treatments by the cold shake method. Rehydration was also coniderably poorer by the cold soak and boiling methods of rehydration than celery that had been dried without pre-treatment, number 8 in Table II. As was the case for all treatments, rehydration was best by the cold shake method. Rehydration by boiling was slightly better than by the cold soak method.

Blanching, when used alone, treatment 3 in Table II, inhibited rehydration of celery considerably when compared with celery that had been dried without pretreatment. The inhibitory effect of blanching was apparent in all methods of rehydration but this treatment was one of two in which the dried celery rehydrated to a slightly higher average value by the cold soak method than by the rapid boil method.

The inhibitory effect of the blanching treatment on rehydration was also apparent when blanching was followed by some of the other treatments. Six of nine treatments that included blanching resulted in celery that rehydrated more poorly by all three methods of rehydration than celery that had been dried without pretreatment. In addition to blanching only these were treatments numbered (2) blanching followed by puffing, (4) blanching followed by pressing and puffing, (5) blanching followed by freezing, (6) blanching followed by pressing and (7) blanching followed by freezing and pressing.

Freezing, treatment 12 in Table II, was the only single treatment that improved rehydration of celery by the cold shake method. Rehydration was poor, however, by the rapid, boil method. Freezing was one of two predrying treatments that produced celery that rehydrated better by the cold soak method than by boiling.

Freezing was part of all seven predrying treatments that improved rehydration of celery by the cold shake method. Celery that was puffed after freezing, treatment 9 in Table II, did not rehydrate as well as celery that was frozen only, but rehydrated better than the untreated control, treatment 8. The frozen and puffed celery rehydrated better in boiling water than celery that had been frozen only and also better than the untreated control.

The detrimental effects of both blanching and puffing to rehydration by the cold shake method were overcome when freezing was added to the treatment.

The best average rehydration by the cold shake method was with celery that had been steam blanched, frozen, pressed, and then puffed before drying, treatment 15 in Table II. The average recovery of 64.7 percent of the fresh celery weight required an average absorption of 31.7 times its weight of water during rehydration to compensate for an average loss of 55.8 percent of the celery solids during predrying treatment.

When rehydrated by the cold shake method, celery receiving treatment 15 was uniform and had an appearance normal for freshly cooked celery. The texture was crisp, crunchy, and free from objectionable fiber, but the celery lacked flavor.

The degree of rehydration of celery receiving treatment 15 was comparable to celery that was vacuum freeze dried. Celery from the November 29 harvest, when prepared by these two meth-

Table II. Effect of predehydration treatment of 1/4-in. cut celery on loss of solids, yield of dried celery, and yield of rehydrated celery. Pretreatments arranged in order of increasing rehydration by the cold shake method. Drying temperature 160°F. Values are averages of four lots of celery.

Treatment No.	Loss of solids %	Yield, % of theoretical[1]	Predehydration treatment	Yield of rehydrated celery % of original fresh weight by, Cold shake	Cold soak	Boil
1.	2.3	96.1	puff	26.8	18.0	20.5
2.	21.6	81.6	blanch, puff	27.9	16.0	21.7
3.	14.3	82.3	blanch	30.6	19.9	18.2
4.	52.8	44.6	blanch, press & puff	30.7	14.5	23.8
5.	36.8	66.0	blanch & freeze	31.1	16.0	17.4
6.	53.0	45.6	blanch & press	31.6	14.1	15.9
7.	54.8	44.4	blanch, freeze & press	38.6	14.0	18.5
8.	0.0	99.3	none	39.7	29.7	26.1
9.	13.6	87.3	freeze, puff	48.5	24.6	29.5
10.	47.4	56.4	freeze, press & puff	55.7	21.8	30.1
11.	62.9	35.5	blanch, freeze, press, leach, press & puff	56.1	28.4	43.8
12.	10.1	88.6	freeze	58.6	24.8	18.4
13.	36.3	64.3	blanch, freeze puff	60.6	21.4	39.1
14.	44.2	54.4	freeze & press	63.9	21.8	20.5
15.	55.8	42.8	blanch, freeze, press & puff	64.7	20.4	46.8

[1]Computed from the difference between the weight of moisture free solids in the starting celery and in the celery recovered from the dryer.

ods, rehydrated to the same degree, 70.0% of fresh weight, by the cold shake method. The rehydrated celery from vacuum freeze drying was not as crisp and crunchy but had a much more pronounced celery flavor.

Celery receiving treatments listed under numbers 10 through 14, Table II, all rehydrated well by the cold shake method. In these treatments, freezing before drying, number 12, Table II, is of special interest because of its simplicity and because losses in soluble solids were low. Yields of dried celery were therefore highest among all treatments that resulted in better rehydration than the untreated control and the rehydrated product best retained non-volatile flavors.

In subsequent pilot plant-scale preparations the freeze treatment was modified by freezing the celery in the drying tray and then placing it in the dryer without thawing. This reduced losses in soluble solids and improved rehydration so that it was comparable or better than celery receiving treatment 15. Freezing followed by hot air drying, conducted to avoid losses from drip, would appear to be the procedure of choice for preparing dehydrated celery where speed of rehydration is not essential.

Removal of additional soluble solids from celery receiving treatment 15 by water leaching for three hours after pressing, treatment 11, did not result in improved rehydration. In a special study, not shown in Table II, celery was leached overnight after blanching and then reblanched and again leached overnight. During this treatment the celery lost 65.2 percent of its total solids content· Rehydration was considerably lower by all methods of rehydration than similar celery that had only been blanched before drying. When celery that had been blanched and leached, reblanched and releached was frozen, pressed and puffed before drying, rehydration was only slightly lower than celery that had received only the treatment listed under 15, Table II. These results indicate that soluble solids naturally present in celery do not contribute to poor rehydration and may serve to improve it.

Rapid rehydration in hot water *is essential* for dehydrated celery that is used in consumer products such as dried soups and stews. For this reason rehydration in boiling water has been the method used in this laboratory in previous studies on celery dehydration (1 and 2).

Celery that had been steam blanched, frozen, pressed, and puffed before drying, treatment 15, Table II, rehydrated best among all treatments when boiled. Even though rehydration was not as complete, the product obtained was similar in appearance and other qualities to that obtained by the cold shake method of rehydration. In contrast, vacuum freeze dried celery rehydrated as completely during boiling as during cold shaking, but the texture was not as crisp.

Treatment 15 would be the method of choice to produce celery with the best rehydration by the rapid, boil method. The difference in rehydration between treatment 15 and treatment 13, Table II, could be accounted for by failure of some pieces receiving treatment 13 to rehydrate fully. Treatment 15, which substitutes pressing for partial drying before puffing, is therefore an improvement on the blanch, freezze, and puff treatment previously developed by this laboratory (2).

All of the pre-drying treatments were detrimental to rehydration by the cold soak method· Untreated dried celery rehydrated better by the cold soak method than by boiling. This may account for present commercial practice of drying without predrying treatment other than sulfiting, and the recommendation for rehydration by soaking in cold water.

ACKNOWLEDGEMENT

Appreciation is expressed to Mr. James L. Froscher of this Laboratory for preparing the vacuum freeze dried celery used in this study.

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