

## Literature Cited

- (1) Augustinsson, K. B., Heimbürger, G., *Acta. Chem. Scand.* **8**, 1533-41 (1954).
- (2) Averell, P. R., Norris, M. V., *Anal. Chem.* **20**, 753-6 (1948).
- (3) Chamberlain, W. F., Hoskins, W. M., *J. Econ. Entomol.* **44**, 177-91 (1951).
- (4) Claborn, H. V., *U. S. Dept. Agr. ARS 33-25*, July 1956.
- (5) Cook, J. W., *J. Assoc. Offic. Agr. Chemists* **37**, 561-4 (1954).
- (6) *Ibid.*, pp. 987-9.
- (7) *Ibid.*, **38**, 150-3 (1955).
- (8) *Ibid.*, p. 826-32.
- (9) Cook, J. W., Pugh, Nancy, *Ibid.*, **40**, 277-81 (1957).
- (10) Cook, J. W., Sykes, J. F., U. S. Dept. Health, Education, Welfare; U. S. Dept. Agr., unpublished data, 1956.
- (11) Dahm, P. A., Fountaine, F. C., Pankaskie, J. E., Smith, R. C., Atkeson, F. W., *J. Dairy Sci.* **33**, 747-57 (1950).
- (12) Dahm, P. A., Jacobson, N. L., *J. Agr. Food Chem.* **4**, 150-5 (1956).
- (13) Doetsch, R. N., Robinson, R. Q., *J. Dairy Sci.* **36**, 115-42 (1953).
- (14) Ely, R. E., Moore, L. A., Carter, R. H., Mann, H. D., Poos, F. W., *Ibid.*, **35**, 266-71 (1952).
- (15) Ely, R. E., Moore, L. A., Hubanks, P. E., Carter, R. H., Poos, F. W., *Ibid.*, **37**, 294-8, 1461-5 (1954); *Ibid.*, **38**, 669-72 (1955).
- (16) Ely, R. E., Moore, L. A., Mann, H. D., Carter, R. H., *Ibid.*, **35**, 733-7 (1952).
- (17) Fallscheer, H. O., Cook, J. W., *J. Assoc. Offic. Agr. Chemists* **39**, 691-7 (1956).
- (18) Frawley, J. P., Fuyat, H. N., Jr., *J. Agr. Food Chem.* **5**, 346-8 (1957).
- (19) Gage, J. C., *Biochem. J.* **54**, 426-30 (1953).
- (20) Hastings, E. C., *Bacteriol. Rev.* **8**, 235 (1944).
- (21) Hungate, R. E., *Ibid.* **19**, 277-9 (1955).
- (22) Lewis, D., *Biochem. J.* **49**, 149-53 (1951).
- (23) McGregor, W. S., Bushland, R. C., *J. Econ. Entomol.* **49**, 86 (1956).
- (24) Mazur, A., *J. Biol. Chem.* **164**, 271 (1946).
- (25) Metcalf, R. L., March, R. B., *J. Econ. Entomol.* **46**, 288-94 (1953).
- (26) Mounter, L. A., Baxter, R. F., Chanutin, A., *J. Biol. Chem.* **215**, 699-704 (1955).
- (27) Mounter, L. A., Dien, L. T. H., *Ibid.*, **219**, 685-90 (1956).
- (28) Pankaskie, J. E., Fountaine, F. C., Dahm, P. A., *J. Econ. Entomol.* **45**, 51-60 (1952).
- (29) Smith, C. L., Richards, R., *Ibid.*, **48**, 566-8 (1955).
- (30) Wilber, C. G., Morrison, R. A., *Am. J. Vet. Research* **16**, 308-13 (1955).

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## SWEET POTATO CANNING

# Effects of Processing Conditions on the Chemical Properties of Canned Sweet Potatoes

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Effects of processing conditions on the chemical properties of Unit I Porto Rico and Goldrush varieties of sweet potatoes were determined. The  $\beta$ -carotene content of the canned potatoes was relatively stable during processing with values of 20 to 25 mg. per No. 2 can of Unit I Porto Rico sweet potatoes and 40 to 45 mg. per No. 2 can of Goldrush. The dry weight of the cooked potato was about 80% sugar, averaging 120 to 150 grams per No. 2 can when packed in 35°-Brix sugar solution, with the Unit I Porto Rico variety containing more sugar than the Goldrush variety. Ascorbic acid content was reduced during processing.

SWEET POTATO CANNING is an established industry, and the pack in the United States has been reported in the "Biennial Census of Manufacturers" for more than 50 years. Selection of varieties suitable for canning, relationship of storage to canning quality, and canning processes have been determined by numerous investigators (10-16).

Woodroof, DuPree, and Cecil (17) have recently issued a bulletin on the canning of sweet potatoes in which the selection of varieties, the conditions of processing, and the nutritional value of canned sweet potatoes were evaluated.

The effects of raw storage, conditions of processing, and variety on the chemical properties of dehydrated sweet

potato products have been reported by the authors (2-5). These data provide an objective basis for evaluation of the potential nutritive value of the dehydrated products. Similar information on the effects of these variables on the chemical properties of canned sweet potatoes has not been reported in the literature.

The purpose of this report is to present experimental data on the effects of conditions of processing on the chemical properties of canned products prepared from two selected, "moist-type" varieties of sweet potatoes. The relative significance of the observations reported is not likely to be changed by elaboration of the experiments. The broad applicability of the data might or might not be enhanced.

## Methods

**Moisture.** A 2- to 3-gram sample of a slurry of canned sweet potatoes and liquid media was weighed into tared, dry, aluminum weighing dishes (approximately 2 inches in diameter and  $\frac{3}{4}$  inch in depth) with tightly fitting covers. The dishes, with cocked lids, were placed in a vacuum oven, and the samples were dried for 6 hours at 70° C. at a pressure of less than 100 mm. The dishes were covered and allowed to cool in a desiccator before weighing. The percentage of moisture in the original sample was calculated (6).

**Ascorbic Acid.** The visual titration method based on the reduction of 2,6-dichlorophenolindophenol by an acid solution of ascorbic acid was used (9). A 150-gram sample of a slurry of canned sweet potatoes and liquid media was steeped under nitrogen for 15 minutes in a blender with 150 grams of 6% metaphosphoric acid. Thirty grams of this mixture were quantitatively transferred to a 100-ml. volumetric flask and made to volume with 3% metaphosphoric acid. After mixing, the solution was clarified, and an aliquot titrated with 0.025% of 2,6-dichlorophenolindophenol solution to a pink end point which persisted for 15 seconds.

**Carotene.** A 10-gram sample of a slurry of canned sweet potatoes and liquid media was weighed onto a Büchner funnel and washed 3 to 4 times with a small amount of water to remove sugar and soluble starch. The carotene was extracted from the sample by means of 150 ml. of a foaming mixture, containing about 4 volumes of ethyl alcohol and 3 volumes of petroleum ether, in a blender for about 5 minutes. The residue was allowed to settle, and the supernatant liquid was decanted. Sufficient water was added to the liquid to adjust the concentration of alcohol to about 80%, and after the layers separated, the alcohol was drawn off. The residue and alcohol solution were successively extracted with three additional 30-ml. portions of petroleum ether. Then all of the alcohol was removed from the petroleum ether solution by washing six to seven times with 100-ml. portions by water. The petroleum ether solution was concentrated to about 30 ml. by vacuum. A column of calcium di-

**Table I. Analyses of Samples of Raw Sweet Potatoes Harvested and Stored at 60° F. during the 1955-6 Season<sup>a</sup>**

| Variety    | Time in Storage, Months | Moisture, % <sup>b</sup> | $\beta$ -Carotene, P.P.M. | Ascorbic Acid, Mg./100 G. | Sugar, % |
|------------|-------------------------|--------------------------|---------------------------|---------------------------|----------|
| Unit I     |                         |                          |                           |                           |          |
| Porto Rico | 1                       | 68                       | 213                       | 91                        | 15       |
|            | 4                       | 71                       | 228                       | 83                        | 19       |
| Goldrush   | 1                       | 73                       | 572                       | 94                        | 20       |
|            | 4                       | 77                       | 452                       | 80                        | 22       |

<sup>a</sup> Analyses reported on moisture-free basis.  
<sup>b</sup> Moisture on "as is" basis.

phosphate (about 9 cm. in length and 2.2 cm. in diameter with a small quantity of anhydrous sodium sulfate on top) was saturated with petroleum ether; then the solution containing the pigments was drawn through the column, followed by a wash of petroleum ether. The filtrate, containing the carotene which was separated from the other pigments on the column, was added to a volumetric flask and brought to volume. The concentration of  $\beta$ -carotene—i.e., ab-

sorbance of the solution at 436 m $\mu$ —was determined (8).

**Sugar.** The sugar content of a slurry of the liquid media and of the cooked, canned sweet potatoes was estimated as sucrose by a polarimetric procedure (7). Ten grams of the slurry was suspended in 75 ml. of 95% ethyl alcohol, thoroughly mixed, and made up to a volume of 100 ml. with 95% ethyl alcohol. A filtered aliquot was polarized in a 200-mm. tube, and the degrees

**Table II. Effects of Peeling, Cooking, and Sugar Added on the Chemical Properties of Canned Unit I Porto Rico Sweet Potatoes<sup>a</sup>**

| Sugar Added                       |              | $\beta$ -Carotene, Mg./No. 2 Can | Ascorbic Acid, Mg./No. 2 Can | Sugar, G./No. 2 Can | Cut-out, ° Brix |
|-----------------------------------|--------------|----------------------------------|------------------------------|---------------------|-----------------|
| ° Brix                            | G./No. 2 Can |                                  |                              |                     |                 |
| PEELING CONDITION I <sup>b</sup>  |              |                                  |                              |                     |                 |
| Cooking time: 50 min. at 250° F.  |              |                                  |                              |                     |                 |
| 0                                 | 0            | 33                               | 68                           | 111                 | 20              |
| 18                                | ..           | 31                               | 65                           | 112                 | 21              |
| 25                                | 25           | 30                               | 54                           | 133                 | 24              |
| 35                                | 34           | 28                               | 66                           | 145                 | 33              |
| Cooking time: 70 min. at 250° F.  |              |                                  |                              |                     |                 |
| 0                                 | 0            | 28                               | 47                           | 88                  | 18              |
| 18                                | ..           | 27                               | 41                           | 114                 | 21              |
| 25                                | 23           | 28                               | 52                           | 130                 | 24              |
| 35                                | 39           | 24                               | 55                           | 144                 | 25              |
| Cooking time: 90 min. at 250° F.  |              |                                  |                              |                     |                 |
| 0                                 | 0            | 24                               | 51                           | 106                 | 19              |
| 18                                | ..           | 27                               | 52                           | 115                 | 21              |
| 25                                | 30           | 30                               | 47                           | 128                 | 24              |
| 35                                | 19           | 23                               | 63                           | 125                 | 26              |
| PEELING CONDITION II <sup>c</sup> |              |                                  |                              |                     |                 |
| Cooking time: 50 min. at 250° F.  |              |                                  |                              |                     |                 |
| 0                                 | 0            | 22                               | 64                           | 92                  | 16              |
| 18                                | 36           | 30                               | 58                           | 125                 | 23              |
| 25                                | 62           | 26                               | 29                           | 146                 | 25              |
| 35                                | 87           | 25                               | 35                           | 172                 | 29              |
| Cooking time: 70 min. at 250° F.  |              |                                  |                              |                     |                 |
| 0                                 | 0            | 24                               | 30                           | 103                 | 18              |
| 18                                | 41           | 27                               | 36                           | 130                 | 23              |
| 25                                | 43           | 27                               | 36                           | 118                 | 23              |
| 35                                | 74           | 25                               | 44                           | 158                 | 28              |
| Cooking time: 90 min. at 250° F.  |              |                                  |                              |                     |                 |
| 0                                 | 0            | 24                               | 30                           | 92                  | 17              |
| 18                                | 35           | 23                               | 36                           | 120                 | 22              |
| 25                                | 55           | 24                               | 42                           | 130                 | 24              |
| 35                                | 74           | 24                               | 47                           | 157                 | 30              |

of rotation read. The sugar in the sample was estimated as sucrose by comparing the reading with a standard sucrose curve. This estimate does not take into account the higher specific rotation of maltose, which may comprise a substantial proportion of sugar in the processed product. Hence, the values for sugar may be higher than the true values.

**Drained Weight.** The drained weight of sweet potatoes in a can of product was determined by pouring the contents through a No. 8 screen. After draining for 2 minutes, the weight of product remaining on the screen was recorded as drained weight.

**Processing Tests.** About 135 pounds of sweet potatoes were washed with water, preheated for 35 minutes at 130° F. in water where indicated, and then dumped into a rotary lye peeler (7). The peeling conditions were as follows: lye concentration, 10 or 20% as indicated; temperature, 210° to 220° F.; time, 6 minutes. From the peeler the

sweet potatoes were dropped into a rotary-spray water washer, where the lye and peelings were removed in 1 to 1.5 minutes. The peeled and washed potatoes were moved to a trimmer who manually cut off the ends and scar tissue.

The peeled and trimmed potatoes were placed in No. 2 standard enamel cans. Either water or 18°, 25°, or 35°-Brix cane sugar solutions (heated to 180° to 190° F.) were added, as indicated, to the canned potatoes. The cans, containing the solution and potatoes, were heated for 4 minutes in a hot water (about 200° F.) exhaust box and sealed while hot by an electrically operated machine. The sealed, canned product was placed in a retort and cooked for 50, 70, or 90 minutes, as indicated, at 250° F. After cooling in the retort, by means of water sprays, the canned product was removed and stored at 60° F. for a minimum of 1 month prior to making the analyses of the products reported herein.

**Other Tests.** The vacuum in the cans was measured just prior to removing samples for analytical tests and usually varied from 5 to 7 inches. The color and texture of the canned products were also subjectively evaluated at the time of sampling and were usually yellow to orange and soft to firm, respectively.

### Materials

The investigations were conducted during the 1955-56 season on sweet potatoes of the Unit I Porto Rico and Goldrush varieties grown in Louisiana. The potatoes were harvested about October 15 and cured for 10 days at 85° F. under 80 to 85% relative humidity on the farm where they were grown. Then the potatoes were shipped to the Southern Regional Research Laboratory and placed in storage at 60° F. The processing investigations were conducted on sweet potatoes held in raw storage for 1 to 2 months and were repeated on other samples of the same sweet potatoes held in raw storage for 4 to 5 months. The analytical data on samples of raw materials taken at 1 and 4 months of raw storage are given in Table I.

### Results

The effects of peeling, cooking, and sugar added on the chemical properties of canned Unit I Porto Rico sweet potatoes are shown in Table II. The canned products were prepared from sweet potatoes withdrawn between the first and second months from storage at 60° F. These studies were replicated on sweet potatoes withdrawn between the fourth and fifth months from storage at 60° F. Similar qualitative and quantitative data were obtained.

A minimum of one case (24 No. 2 cans) of product was prepared for each test. The results, reported in Table II, are averages of duplicate analyses run on each of two different cans selected from the test sample.

Considering the variations in physical size and shape of the potatoes, which determined the volume of liquid medium added to each can, and the problems of obtaining uniform analytical samples, the following conclusions may be drawn:

1. As compared with the raw stock the amount of  $\beta$ -carotene retained was not affected by peeling, cooking, or sugar added.

2. The amount of ascorbic acid retained was not affected by the sugar added, but was substantially reduced by processing and was apparently slightly further reduced from longer cooking times particularly when combined with peeling in higher concentrations of lye.

3. The amount of sugar added, of course, generally increased as the concentration of sugar in the liquid medium added increased. The amount of sugar in the canned product increased to a

**Table II. Effects of Peeling, Cooking, and Sugar Added on the Chemical Properties of Canned Unit I Porto Rico Sweet Potatoes<sup>a</sup> (Continued)**

| Sugar Added                        |              | $\beta$ -Carotene,<br>Mg./No. 2 Can | Ascorbic Acid,<br>Mg./No. 2 Can | Sugar,<br>G./No. 2 Can | Cut-out,<br>° Brix |
|------------------------------------|--------------|-------------------------------------|---------------------------------|------------------------|--------------------|
| ° Brix                             | G./No. 2 Can |                                     |                                 |                        |                    |
| PEELING CONDITION III <sup>d</sup> |              |                                     |                                 |                        |                    |
| Cooking time: 50 min. at 250° F.   |              |                                     |                                 |                        |                    |
| 0                                  | 0            | 28                                  | 37                              | 124                    | 20                 |
| 18                                 | 32           | 35                                  | 35                              | 146                    | 24                 |
| 25                                 | 51           | 29                                  | 55                              | 141                    | 26                 |
| 35                                 | 63           | 25                                  | 47                              | 158                    | 28                 |
| Cooking time: 70 min. at 250° F.   |              |                                     |                                 |                        |                    |
| 0                                  | 0            | 28                                  | 29                              | 113                    | 19                 |
| 18                                 | 15           | 26                                  | 15                              | 123                    | 22                 |
| 25                                 | 45           | 27                                  | 53                              | 133                    | 26                 |
| 35                                 | 85           | 23                                  | 27                              | 174                    | 30                 |
| Cooking time: 90 min. at 250° F.   |              |                                     |                                 |                        |                    |
| 0                                  | 0            | 29                                  | 36                              | 95                     | 18                 |
| 18                                 | 33           | 28                                  | 38                              | 136                    | 23                 |
| 25                                 | 38           | 23                                  | 47                              | 127                    | 25                 |
| 35                                 | 81           | 27                                  | 39                              | 173                    | 30                 |
| PEELING CONDITION IV <sup>e</sup>  |              |                                     |                                 |                        |                    |
| Cooking time: 50 min. at 250° F.   |              |                                     |                                 |                        |                    |
| 0                                  | 0            | 24                                  | 20                              | 91                     | 17                 |
| 18                                 | 20           | 30                                  | 24                              | 127                    | 22                 |
| 25                                 | 37           | 26                                  | 54                              | 119                    | 25                 |
| 35                                 | 57           | 28                                  | 43                              | 160                    | 26                 |
| Cooking time: 70 min. at 250° F.   |              |                                     |                                 |                        |                    |
| 0                                  | 0            | 26                                  | 17                              | 102                    | 16                 |
| 18                                 | 31           | 28                                  | 33                              | 134                    | 24                 |
| 25                                 | 49           | 26                                  | 46                              | 128                    | 25                 |
| 35                                 | 61           | 27                                  | 27                              | 160                    | 27                 |
| Cooking time: 90 min. at 250° F.   |              |                                     |                                 |                        |                    |
| 0                                  | 0            | 27                                  | 19                              | 108                    | 17                 |
| 18                                 | 15           | 24                                  | 38                              | 118                    | 22                 |
| 25                                 | 39           | 30                                  | 38                              | 133                    | 26                 |
| 35                                 | 26           | 32                                  | 38                              | 126                    | 25                 |

<sup>a</sup> Raw sweet potatoes equivalent to that added to average No. 2 can contained: 23 to 30 mg.  $\beta$ -carotene; 98 to 126 mg. ascorbic acid; 16 to 20 g. sugar.

<sup>b</sup> Preheated in water for 35 min. at 130° F. and peeled in 10% sodium hydroxide for 6 min. at 220° F.

<sup>c</sup> Same as <sup>b</sup> except no preheating.

<sup>d</sup> Preheated in water for 35 min. at 130° F. and peeled in 20% sodium hydroxide for 6 min. at 220° F.

<sup>e</sup> Same as <sup>d</sup> except no preheating.

**Table III. Materials Balance for Canned Unit I Porto Rico Sweet Potatoes**

| Sugar Added,<br>° Brix             | Drained Wt.,<br>G./No. 2 Can | Liquid,<br>Ml./No. 2 Can | Liquid,<br>G./No. 2 Can | Dry Wt.,<br>G./No. 2 Can |
|------------------------------------|------------------------------|--------------------------|-------------------------|--------------------------|
| PEELING CONDITION I <sup>a</sup>   |                              |                          |                         |                          |
| Cooking time: 50 min. at 250° F.   |                              |                          |                         |                          |
| 0                                  | 429                          | 162                      | 175                     | 133                      |
| 18                                 | 407                          | 192                      | 208                     | 135                      |
| 25                                 | 416                          | 175                      | 192                     | 164                      |
| 35                                 | 446                          | 150                      | 171                     | 173                      |
| Cooking time: 70 min. at 250° F.   |                              |                          |                         |                          |
| 0                                  | 406                          | 176                      | 189                     | 113                      |
| 18                                 | 391                          | 204                      | 221                     | 141                      |
| 25                                 | 413                          | 171                      | 188                     | 162                      |
| 35                                 | 415                          | 200                      | 221                     | 178                      |
| Cooking time: 90 min. at 250° F.   |                              |                          |                         |                          |
| 0                                  | 394                          | 200                      | 215                     | 171                      |
| 18                                 | 354                          | 236                      | 256                     | 140                      |
| 25                                 | 438                          | 130                      | 189                     | 169                      |
| 35                                 | 441                          | 132                      | 146                     | 158                      |
| PEELING CONDITION II <sup>b</sup>  |                              |                          |                         |                          |
| Cooking time: 50 min. at 250° F.   |                              |                          |                         |                          |
| 0                                  | 343                          | 210                      | 224                     | 102                      |
| 18                                 | 398                          | 186                      | 204                     | 144                      |
| 25                                 | 391                          | 195                      | 215                     | 170                      |
| 35                                 | 416                          | 172                      | 193                     | 195                      |
| Cooking time: 70 min. at 250° F.   |                              |                          |                         |                          |
| 0                                  | 383                          | 190                      | 204                     | 117                      |
| 18                                 | 372                          | 206                      | 225                     | 149                      |
| 25                                 | 388                          | 196                      | 214                     | 151                      |
| 35                                 | 360                          | 240                      | 268                     | 182                      |
| Cooking time: 90 min. at 250° F.   |                              |                          |                         |                          |
| 0                                  | 355                          | 206                      | 220                     | 104                      |
| 18                                 | 368                          | 210                      | 229                     | 143                      |
| 25                                 | 388                          | 207                      | 227                     | 163                      |
| 35                                 | 385                          | 216                      | 243                     | 182                      |
| PEELING CONDITION III <sup>c</sup> |                              |                          |                         |                          |
| Cooking time: 50 min. at 250° F.   |                              |                          |                         |                          |
| 0                                  | 419                          | 156                      | 168                     | 129                      |
| 18                                 | 438                          | 170                      | 191                     | 157                      |
| 25                                 | 398                          | 186                      | 206                     | 176                      |
| 35                                 | 465                          | 144                      | 162                     | 188                      |
| Cooking time: 70 min. at 250° F.   |                              |                          |                         |                          |
| 0                                  | 445                          | 160                      | 173                     | 130                      |
| 18                                 | 355                          | 230                      | 252                     | 140                      |
| 25                                 | 417                          | 184                      | 208                     | 170                      |
| 35                                 | 356                          | 246                      | 280                     | 210                      |
| Cooking time: 90 min. at 250° F.   |                              |                          |                         |                          |
| 0                                  | 414                          | 176                      | 192                     | 115                      |
| 18                                 | 400                          | 188                      | 208                     | 158                      |
| 25                                 | 462                          | 134                      | 147                     | 163                      |
| 35                                 | 406                          | 208                      | 237                     | 206                      |
| PEELING CONDITION IV <sup>d</sup>  |                              |                          |                         |                          |
| Cooking time: 50 min. at 250° F.   |                              |                          |                         |                          |
| 0                                  | 336                          | 194                      | 207                     | 130                      |
| 18                                 | 392                          | 178                      | 194                     | 141                      |
| 25                                 | 390                          | 178                      | 196                     | 158                      |
| 35                                 | 421                          | 192                      | 213                     | 178                      |
| Cooking time: 70 min. at 250° F.   |                              |                          |                         |                          |
| 0                                  | 345                          | 222                      | 236                     | 116                      |
| 18                                 | 414                          | 156                      | 171                     | 152                      |
| 25                                 | 397                          | 170                      | 188                     | 170                      |
| 35                                 | 407                          | 200                      | 222                     | 182                      |
| Cooking time: 90 min. at 250° F.   |                              |                          |                         |                          |
| 0                                  | 344                          | 220                      | 235                     | 116                      |
| 18                                 | 375                          | 174                      | 190                     | 136                      |
| 25                                 | 396                          | 142                      | 157                     | 160                      |
| 35                                 | 409                          | 124                      | 137                     | 147                      |

<sup>a</sup> Preheated in water for 35 min. at 130° F. and peeled in 10% NaOH for 6 min. at 220° F

<sup>b</sup> Same as <sup>a</sup> except no preheating.

<sup>c</sup> Preheated in water for 35 min. at 130° F. and peeled in 20% NaOH for 6 min. at 220° F.

<sup>d</sup> Same as <sup>c</sup> except no preheating.

greater extent than accounted for by the sirup added, due to the change of starch in the potatoes to sugar. However, the magnitude of the increase was apparently not affected by the concentration of sugar in the liquid media added, the cooking times, or the peeling conditions investigated.

4. After canning, the °Brix of the liquid media cut-out was related to the °Brix of the media added. For added liquid media of 0° and 18° Brix, the cut-out °Brix was greater than the added °Brix; for added liquid media of 25° Brix, the cut-out °Brix was approximately the same; and for added liquid media of 35° Brix, the cut-out °Brix was less than the added °Brix. Peeling and cooking apparently did not affect the results.

The effects of peeling, cooking, and sugar added on the materials balance for canned Unit I Porto Rico sweet potatoes are shown in Table III. The total of the drained weight and liquid weight for each experimental condition was relatively constant. There was no apparent systematic variation of liquid volume, or weight, or of drained weight with processing conditions. As would be expected, considering the variables previously mentioned, products canned in liquid media having the highest sugar concentration had the highest dry weight.

The effects of cooking time and sugar added on the chemical properties and on the materials balance for canned Goldrush sweet potatoes are shown in Tables IV and V, respectively. As in the case of Unit I Porto Rico, the amount of β-carotene retained was not affected by cooking time or sugar added; but the amount of β-carotene in both the raw stock and the processed product was approximately twice that for the Unit I Porto Rico variety. The ascorbic acid was reduced by processing and was not affected by the added sugar. The increase of sugar in the product, due to change of starch to sugar in the potatoes, increased with processing but was lower than that for the Unit I Porto Rico variety. Probably, as a result of this fact, the cut-out °Brix, although qualitatively similar to that for the Unit I Porto Rico variety, was lower for the Goldrush variety.

The drained and liquid weights were relatively constant under all conditions of processing, and their total weight about equalled that for the Unit I Porto Rico variety. However, the dry weight per unit of product was lower for the Goldrush variety than for the Unit I Porto Rico variety.

The results of replicated experiments with the Unit I Porto Rico variety, although about the same as the results of the initial experiments, showed some significant differences in the raw-materials processing balances as shown in Table VI. The effects of processing on

**Table IV. Effects of Cooking Time and Sugar Added on the Chemical Properties of Canned Goldrush Sweet Potatoes<sup>a</sup>**

| Sugar Added                      |              | β-Carotene,<br>Mg./No. 2 Can | Ascorbic Acid,<br>Mg./No. 2 Can | Sugar,<br>G./No. 2 Can | Cut-out,<br>° Brix |
|----------------------------------|--------------|------------------------------|---------------------------------|------------------------|--------------------|
| ° Brix                           | G./No. 2 Can |                              |                                 |                        |                    |
| Cooking time: 50 min. at 250° F. |              |                              |                                 |                        |                    |
| 0                                | 0            | 43                           | 35                              | 59                     | 13                 |
| 18                               | 38           | 45                           | 32                              | 91                     | 19                 |
| 25                               | 61           | 43                           | 38                              | 112                    | 22                 |
| 35                               | 96           | 47                           | 40                              | 146                    | 27                 |
| Cooking time: 70 min. at 250° F. |              |                              |                                 |                        |                    |
| 0                                | 0            | 45                           | 36                              | 61                     | 14                 |
| 18                               | 39           | 48                           | 49                              | 89                     | 19                 |
| 25                               | 53           | 42                           | 46                              | 106                    | 22                 |
| 35                               | 90           | 45                           | 44                              | 135                    | 26                 |
| Cooking time: 90 min. at 250° F. |              |                              |                                 |                        |                    |
| 0                                | 0            | 44                           | 37                              | 68                     | 14                 |
| 18                               | 21           | 41                           | 28                              | 80                     | 18                 |
| 25                               | 36           | 47                           | 37                              | 92                     | 21                 |
| 35                               | 74           | 44                           | 46                              | 123                    | 24                 |

<sup>a</sup> Raw sweet potatoes equivalent to that added to average No. 2 can contained: 41 to 52 mg. β-carotene; 73 to 86 mg. ascorbic acid; 18 to 20 grams sugar.

**Table V. Materials Balance for Canned Goldrush Sweet Potatoes<sup>a</sup>**

| Sugar Added,<br>° Brix           | Drained Wt.,<br>G./No. 2 Can | Liquid,<br>Ml./No. 2 Can | Liquid,<br>G./No. 2 Can | Dry Wt.,<br>G./No. 2 Can |
|----------------------------------|------------------------------|--------------------------|-------------------------|--------------------------|
| Cooking time: 50 min. at 250° F. |                              |                          |                         |                          |
| 0                                | 386                          | 178                      | 188                     | 86                       |
| 18                               | 402                          | 175                      | 189                     | 124                      |
| 25                               | 410                          | 188                      | 203                     | 147                      |
| 35                               | 402                          | 200                      | 222                     | 182                      |
| Cooking time: 70 min. at 250° F. |                              |                          |                         |                          |
| 0                                | 400                          | 168                      | 176                     | 92                       |
| 18                               | 435                          | 149                      | 160                     | 131                      |
| 25                               | 402                          | 161                      | 176                     | 145                      |
| 35                               | 411                          | 194                      | 215                     | 182                      |
| Cooking time: 90 min. at 250° F. |                              |                          |                         |                          |
| 0                                | 400                          | 185                      | 194                     | 95                       |
| 18                               | 390                          | 151                      | 162                     | 116                      |
| 25                               | 396                          | 161                      | 175                     | 131                      |
| 35                               | 417                          | 170                      | 186                     | 169                      |

<sup>a</sup> Raw sweet potatoes (total of 405 pounds in three 135-pound runs), maintained in raw storage at 60° F. for 44 to 46 days, were preheated in water for 35 min. at 130° F. and peeled in 20% sodium hydroxide for 6 min. at 220° F. Average peeling and trimming losses were 26 and 4%, respectively.

**Table VI. Raw Materials Processing Balance for Unit I Porto Rico Sweet Potatoes<sup>a</sup>**

| Preheat   | No Preheat | Peeling Conditions for 6 Min. at 220° F. |          | Trimming Losses,<br>% | Peeling Losses,<br>% | Yield,<br>% |
|---|------------|--|----------|-----------------------|----------------------|-------------|
|   |            | 10% NaOH                                 | 20% NaOH |                       |                      |             |
| Raw sweet potatoes stored for 1 to 2 months at 60° F. |            |  |          |                       |                      |             |
| -   | +          | +  | -        | 7                     | 23                   | 70          |
| +   | -          | +  | -        | 5                     | 24                   | 71          |
| -   | +          | -  | +        | 8                     | 22                   | 70          |
| +   | -          | -  | +        | 6                     | 24                   | 70          |
| Raw sweet potatoes stored for 4 to 5 months at 60° F. |            |  |          |                       |                      |             |
| -   | +          | +  | -        | 19                    | 17                   | 64          |
| +   | -          | +  | -        | 16                    | 15                   | 69          |
| -   | +          | -  | +        | 15                    | 18                   | 67          |
| +   | -          | -  | +        | 9                     | 22                   | 69          |

<sup>a</sup> + indicates operation took place; - indicates operation did not take place.

the distribution of the trimming and peeling losses were not significant on sweet potatoes withdrawn after 1 to 2 months of storage. On sweet potatoes withdrawn after 4 to 5 months of storage the trimming losses increased and the peeling losses decreased, as compared with sweet potatoes withdrawn after 1 to 2 months of storage, except when the potatoes were preheated and then peeled in 20% sodium hydroxide. Under the latter processing condition, the trimming and peeling losses remained about the same as in the initial experiments. These results may indicate that, with stored Unit I Porto Rico sweet potatoes, the manual trimming may be decreased by preheating and then peeling in a bath having a high lye concentration.

The study reported is not intended to show ranges, averages, and the like for all variations in sweet potatoes; but it is largely intended to report objective observations made under limited and defined experimental conditions.

**Literature Cited**

- (1) Arthur, J. C., Jr., McLemore, T. A., *Food Technol.* **10**, 541-3 (1956).
- (2) Arthur, J. C., Jr., McLemore, T. A., *J. Agr. Food Chem.* **3**, 782-7 (1955).
- (3) *Ibid.*, **4**, 553-5 (1956).
- (4) Arthur, J. C., Jr., McLemore, T. A., *Proc. Assoc. Southern Agr. Workers* **51**, 135 (1954).
- (5) Arthur, J. C., Jr., McLemore, T. A., Miller, J. C., Jones, L. G., Sistrunk, W. A., *J. Agr. Food Chem.* **3**, 1-5 (1955).
- (6) Assoc. Offic. Agr. Chemists, Washington, D. C., "Official Methods of Analysis," 7th ed., p. 320, 1950.
- (7) *Ibid.*, p. 497.
- (8) *Ibid.*, p. 770.
- (9) Assoc. of Vitamin Chemists, Inc., "Methods of Vitamin Assay," 2nd ed., pp. 76-81, Interscience New York, 1951.
- (10) Culpepper, C. W., Magoon, C. A., *J. Agr. Research* **33**, 627-43 (1926).
- (11) Huffington, J. M., Giggard, E. D., Steinbauer, C. E., Walls, E. P., *Food Packer* **35**, No. 3, 38, 40, 54-5, 57 (1954); *Proc. Am. Soc. Hort. Sci.* **61**, 487-95 (1953).
- (12) Lutz, J. M., *Canner* **109**, No. 10, 15-6 (1949).
- (13) Magoon, C. A., Culpepper, C. W., *U. S. Dept. Agr. Infor. Bull.* **1041**, 34 pp. (1922).
- (14) *Ibid.*, **1265**, 28-33 (1924).
- (15) Sistrunk, W. A., Miller, J. C., Jones, L. G., *Food Technol.* **8**, 223-6 (1954).
- (16) Wayley, J. F., *The Crown* **30**, No. 2, 17 (1941).
- (17) Woodroof, J. G., DuPree, W. E., Cecil, S. R., *Georgia Agr. Expt. Sta. Bull.* **N.S. 12**, 60 pp. (1955).

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