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The Effect of Curing and Storage on Chemical Composition and Taste Acceptability of Winter Squash[1]

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CURING winter squash for 10 to 20 days at 70 to 80°F prior to storing has been a frequent recommendation. The beneficial effects attributed to curing include quicker healing of wounds incidental to harvesting and the maturation of immature fruits. McColloch (6) supported this recommendation for all varieties except Acorn. MacGillivray (5) recommended a curing treatment of 80–85° for slightly immature fruits. Yeager, *et al.* (13) recommended circulating air at 80° during the first 2 weeks of storage to dry Hubbard squashes, while Thompson and Kelly (12) made a general recommendation of a 2-week curing period at 75–80°. However, Platinius, *et al.* (9) found little value in high temperature curing for controlling subsequent storage decays. Guba (3) confirmed Platinius' work and suggested that storage temperatures should not be elevated higher than a level adequate to prevent fruit sweating. Hardenburg, *et al.* (4) and Shoemaker (10) omitted mentioning any curing treatments in their recommendations for storing squashes.

Considerable information is in the literature on the changes in chemical composition of pumpkin and squash varieties during growth and storage, and some culinary tests have been reported principally on the canned product. The classical study of Culpepper and Moon (2) on 36 pumpkin and squash varieties summed up most phases of chemical composition. They also ranked the canned product in order of preference based on color, flavor and consistency. The order of color preference was almost the same as the intensity of the yellow color of the carotenoid pigment.

Merrow and Hopp (7) have recently published the results of a storage study of 6 squash varieties. They reported a positive correlation between sugar content and preference in those varieties with low starch-sugar ratios, i.e. Buttercup, Silver Bell, Blue Baby and a negative correlation between sugar content and preference in those squashes with a high sugar-starch ratio, i.e. Blue Hubbard and Butternut.

Some of the studies concerned with chemical composition and taste preference include a curing treatment at an elevated temperature as part of their storage procedure, but none have compared this treatment directly with samples stored without curing.

Some preliminary work by the junior author indicated a highly significant effect from curing the Table Queen variety. Fifteen panelists scored the non-cured squash at 3.33 and the cured at 2.13 on a scale of 5–excellent, 3–average, and 1–unacceptable. The present study was undertaken to determine the effect of a curing treatment

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on eating quality of 4 varieties commonly stored and sold in the fresh market during the winter months.

Objective measurements for color of the cooked product and chemical composition tests were conducted to determine as far as possible what factors the panels were evaluating in their taste preference scores.

Materials and Methods

Four varieties of winter squash, Butternut *(Cucurbita moschata)*, Table Queen *(Cucurbita pepo)*, Blue Hubbard and Quality *(Cucurbita maxima)* were field grown and harvested prior to heavy frost in 1959 and 1960.

After harvesting, 15 to 30 fruits of each variety were subjected to each of the following conditions.

1. Placed in common storage in the basement of an unheated building where the temperature ranged from 50 to 60° F and the relative humidity from 30 to 90%. The temperature was maintained above 50° by a thermostatically controlled electric heater. The squashes were stored one layer deep on slatted shelves.
2. Cured at 80° F for 3 weeks then placed in common storage.
3. Held at 40° F for 3 weeks then placed in common storage.

Taste Tests: Three taste tests were conducted each year to evaluate the squashes. The first panel in 1959 rated the squashes on the basis of eating quality only, whereas all subsequent panels made subjective ratings for degree of fibrousness as well as for eating quality.

The first season's taste tests were conducted on October 15, December 8, 1959 and February 17, 1960. The second season's tests were conducted on October 14, December 15, 1960 and February 9, 1961. The squashes to be tested were selected at random, longitudinal sections removed and baked at 400° F for 1½ hours. Five to 8 fruits of Butternut and Table Queen and 3 to 5 fruits of Blue Hubbard and Quality were used for each test. After cooking, the edible portions of each replicate were combined by variety and treatment and served hot without seasoning.

Calvin's incomplete balanced block design (1) was used for the taste tests. There were 22 panelists on the first test of 1959, with each panelist testing 6 samples, and each sample being rated 11 times. For all subsequent tests the 40° F treatment was omitted. Thereafter each panel was composed of 14 members tasting 4 samples each, with each sample being rated by 7 panelists.

Carbohydrate Analysis: Composite longitudinal sections were taken from each of the raw squashes, the rind removed and then the sections were sliced in a potato chipper. After mixing, 150 g samples were dried in a vacuum chamber at 0.1 mg Hg pressure. Heat lamps directed into the vacuum chamber prevented freezing of the samples. After drying, the samples were ground in a Wiley mill to pass a 40-mesh screen and stored at 0° F. Reducing sugars were determined on the ethanol soluble fraction, starch on the ethanol insoluble fraction, and total sugars by HCl hydrolysis. Reagent preparation and colorimetric techniques were after Nelson (8) and Somogyi (11).

Color and Soluble Solids Determination of the Cooked Squash: Portions of the cooked squash from each taste test were used to determine color reflectance values on the R_d, (diffuse reflectance), *a* (redness + to greenness —) and *b* (yellowness + to blueness —) scales of the Hunter-Color and Color-Difference Meter which had been calibrated with a standard maize SBC 35 plate. A Bausch and Lomb hand refractometer was used to determine the refractive indices of liquids squeezed from the cooked samples with a hand press.

Results

All squashes held at 40° F decayed within 4 weeks after being transferred to common storage. At the time of removal from the low temperature room, most fruits had small sunken spots characteristic of chilling injury. Mature Table Queen and Blue Hubbard varieties had less visible chilling injury than Butternut and Quality. Butternut appeared to be especially susceptible to chilling injury.

Losses from decay were about the same for those fruits cured at an elevated temperature and those not cured prior to storage. Over the entire storage period decay losses were 15 to 20% for the Butternut variety and 5 to 10% for the Blue Hubbard and Quality. Table Queen was affected most by curing at high temperature. The cured fruits developed a bright orange skin color and there was a rapid change in flesh texture. Cured fruits decayed more rapidly than non-cured fruits. These results are in accord with McColloch's (6) observations for this variety.

The 80° F curing treatment was found to be neither beneficial nor detrimental to the storage life of the other 3 varieties. There was an increased weight loss early in the storage period for those fruits cured at 80°, but it was not statistically significant. (Table 1). Since the trend was consistent, it might possibly be of economic importance if the squashes were sold on a weight basis early in the season.

Taste Test Results: The first taste test of October 15, 1959 included a 40° F treatment and for this reason the results are presented separately in Table 2. Treating the squashes at 40° improved the taste of the Table Queen and Quality varieties while curing at 80° improved Butternut. Part of the good score obtained by the Butternut cured at 80° might be attributed to the better color of the cooked product which was more orange-red than the others.

The Butternut variety was the only one which had its taste quality impaired by the 40° F storage treatment. All the squashes in the 40° treatment showed chilling injury, but this type of damage did not lower the taste rating. The low Butternut score of 2.73 was slightly above the mean for the test.

The results of the remaining tests of the 1959–60 season and the

Table 1.—Weight loss of 4 varieties of winter squashes at 3 storage intervals expressed as percent of fresh weight at time of harvest. Average of 2 seasons.

Variety and storage interval	Curing treatment 60 F	Curing treatment 80 F	$\bar{x}$ Variety
Butternut			
30 days	9.3	14.4	
60	19.5	19.0	20.2
90	30.2	28.9	
Table Queen			
30	10.0	17.4	
60	15.3	19.4	18.5
90	21.7	27.2	
Quality			
30	4.7	10.8	
60	9.4	13.7	12.2
90	17.8	16.9	
Blue Hubbard			
30	3.4	6.2	
60	6.0	9.7	7.8
90	8.6	12.8	
Treatment $\bar{x}$	13.0	16.4	
Lsd .05 = 7.9			

Table 2.—Panel scores for eating quality (5–very good, 3–average, 1–very poor) of 4 varieties of squashes cured at 3 temperatures, October 15, 1959.

Treatment	Variety: Butternut	Table Queen	Quality	B. Hubbard
Common storage (60°F)	3.39	1.10	2.33	2.33
Curing at 80°	4.58	1.77	1.58	2.85
Storage at 40°	2.73	3.06	3.83	2.93
L.S.R. (Least significant range) (.01) = 1.17.				

3 tests for the 1960–61 season are shown in Table 3. The results of the last 5 tests indicated no statistically significant advantage to curing squashes at 80° F over immediate storage after harvesting at 50–60° common storage.

Table Queen was generally rated lower than the other 3 varieties except when treated at the 40° F temperature. When cured at 80° this variety developed a very unpalatable flavor variously described by the panels as "sour", "sharp flavor", "strong". Every panel noted it's poor color. The Table Queen results confirmed the observations of the preliminary taste tests, i.e. curing at elevated temperatures lessened its palatability.

Butternut was generally rated highest as a variety and the cured Butternut obtained the highest score in 3 of the 6 panel tests. Most panel comments on this variety were on its sweetness and color, which seemed to appeal to panels more than its flavor attributes. Several panelists commented on its low fiber content. This variety did not keep well past December. In the neck area there was considerable shriveling which did not significantly alter the organoleptic appraisal, but would have made the variety unsaleable due to appearance.

Table 3.—Combined means of taste panel scores for the second and third tests of 1959–60 season and for 1960–61 season (5–very good, 3–average, 1–very poor) for eating quality of 4 varieties of winter squashes cured at 2 temperatures.

Treatment	Variety: Butternut	Table Queen	Quality	B. Hubbard
	1959–60			
Common storage	3.84	2.25	2.10	3.32
Curing at 80°F	4.07	1.44	3.38	2.46
L.S.R. (.05) = 1.27, .01 = 1.79				
	1960–61			
Common storage	3.28	1.96	2.74	2.56
Curing at 80°F	3.60	2.00	3.53	2.46
L.S.R. (.05) = 1.17, .01 = 1.65				

The panel was less consistent in rating the Quality variety than any of the others. As a trend they preferred the cured Quality. Comments on taste ranged from "good flavor" to "bitter", while comments on color were generally favorable.

All taste panels rated the Blue Hubbard variety around the mean of the test. This variety elicited less comment from the panels than others. Some comments were "greatly lacks flavor", "no special flavor".

Taste panel fiber ratings were highly correlated with taste ratings, the coefficient being + .52. Some bias may be associated with the fiber results, *i.e.*, color and flavor estimates may have influenced fiber scores. In general Table Queen and Blue Hubbard were scored as being more fibrous than were Quality and Butternut.

Carbohydrate Analyses: The principal effect from curing squashes at 80° F before storage was to hasten the conversion of starches to total sugars early in the storage period. By December and later sugars in the cured and in the non-cured squash were about equal, (Tables 4, 5).

When the data for the various carbohydrate constituents were plotted against the panel scores, it was obvious from the scatter pattern that no significant correlations existed, either on a fresh weight or dry weight basis. For this reason no statistical correlation coefficients were calculated. Merrow and Hopp (7) showed very good associations between sugars, starches and taste preferences with statistically significant correlation coefficients. Their panel consisted of 5 trained home economists whose taste training probably was better than the panels utilized in this study. Our panels ranged from under 20 to over 70 years in age and were equally male and female. A few of the panelists had had no previous experience with baked squash. The panels were probably representative, however, of the general population.

It seemed apparent that differences in taste panel ratings, especially in the case of the cured Table Queen variety, were due to changes in some other flavor constituents and not due to carbohydrate constituents.

The Influence of Color in Taste Panel Evaluation: The recorded

Table 4.—Carbohydrate constituents as percentages of dry weight. Expressed as reducing sugar equivalent. 1959–60 results.

	Sampling date and treatment						
	10/15/59			12/8/59		2/17/60	
	Cured 40°F	Not cured	Cured 80°F	Not cured	Cured 80°F	Not cured	Cured 80°F
Butternut							
Red. sugars....	16.0	6.3	13.0	5.5	5.2	4.0	6.7
Total sugars...	41.8	31.4	54.3	20.0	20.0	30.0	30.0
Starch........	8.7	28.7	2.5	12.0	6.0	2.0	2.7
Total Carb.....	50.6	60.1	56.8	32.0	26.0	32.0	32.7
Table Queen							
Red. sugars....	3.0	24.0	11.5	4.7	5.7	3.0	2.5
Total sugars...	16.0	28.0	36.0	35.0	30.0	35.0	30.0
Starch........	12.5	2.5	2.5	3.5	4.2	2.2	5.0
Total carb.....	28.5	30.5	38.5	38.5	34.2	37.2	35.0
Quality							
Red. Sugars...	23.5	22.5	20.0	17.0	11.0	27.0	21.0
Total sugars...	32.0	34.0	33.0	30.0	25.0	35.0	40.0
Starch........	20.0	13.7	8.1	5.0	5.0	4.2	2.2
Total carb.....	52.0	47.7	41.1	35.0	30.0	39.2	42.2
Blue Hubbard							
Red. sugars....	37.5	37.5	42.5	23.5	25.5	27.0	33.0
Total sugars...	44.0	50.0	48.0	45.0	50.0	35.0	50.0
Starch........	9.0	2.5	1.2	2.7	3.5	2.0	2.7
Total carb.....	53.0	52.5	49.2	47.7	53.5	37.0	52.7

Table 5.—Carbohydrate constituents as percentages of dry weight. Expressed as reducing sugar equivalent, 1960–61 results.

	Sampling date and treatment						
	At harvest 9/14/60	10/14/60		12/15/60		2/9/61	
		Not cured	Cured 80°F	Not cured	Cured 80°F	Not cured	Cured 80°F
Butternut							
Red. sugars....	8.5	14.5	5.5	17.5	9.0	12.0	8.5
Total sugars...	21.2	33.7	53.7	50.0	52.5	50.0	52.5
Starch........	36.2	27.5	8.7	12.3	5.0	3.2	3.0
Total carb.....	57.5	61.2	62.5	62.3	57.5	53.2	55.5
Table Queen							
Red. sugars....	5.5	22.5	8.0	16.0	18.0	17.5	7.5
Total sugars...	25.0	28.7	40.0	45.0	25.0	30.0	42.5
Starch........	38.7	5.0	5.0	7.5	3.7	3.5	4.2
Total carb.....	63.7	33.7	45.0	52.5	28.7	33.5	46.7
Quality							
Red. sugars....	16.5	28.9	10.0	17.5	29.0	20.0	32.0
Total sugars...	21.2	30.0	41.2	47.5	29.0	37.5	37.5
Starch........	43.7	18.7	28.7	3.5	3.7	7.2	10.7
Total carb.....	65.0	48.7	70.0	51.0	32.7	44.7	48.2
Blue Hubbard							
Red. sugars....	49.5	22.0	25.0	48.0	46.5	48.0	49.5
Total sugars...	56.3	22.0	55.0	50.0	46.5	48.0	52.5
Starch........	2.5	2.5	3.7	2.7	3.7	0.5	2.0
Total carb.....	58.8	24.5	58.7	52.7	52.2	48.5	54.5

comments of the panelists and the consistantly high scores given to the deep orange and yellow colored samples indicated that color was a factor of importance in the evaluation of a sample. The simple correlation coefficients for the Hunter R_d values and taste preference were not statistically significant, indicating that sample lightness to darkness was not an important consideration. In the

1959–60 season the simple correlation coefficient for Hunter *a* reading and taste was — .495 and for Hunter *b* and taste it was + .531. The multiple correlation coefficient was + .599 and the coefficient of determination was .34, all significant at 1%. In the 1960–61 season the simple correlation coefficient for Hunter *a* and taste was a highly significant — .623. The correlation coefficient for Hunter *b* and taste was + .386, not significant. The multiple correlation coefficient was — .623 also significant at 1% and the coefficient of determination was .39. When all data for taste preference and Hunter readings were combined in one multiple correlation analysis, the correlation coefficient was + .584, significant at 1%, and the coefficient of determination was .34. The graphic values of the Hunter *a* and *b* readings are found in Figure 1. The Table Queen variety, which was lowest in yellow component, also was lowest in taste evaluation. Butternut, which was highest in yellow component received the highest taste scores. These results substantiated the observations of Culpepper and Moon (2).

Refractive Indices of Cooked Squash Samples: The refractive indices of cooked squash samples, representing for the most part sugars, were not correlated with taste panel evaluations. The correlation coefficient .10 was not significant.

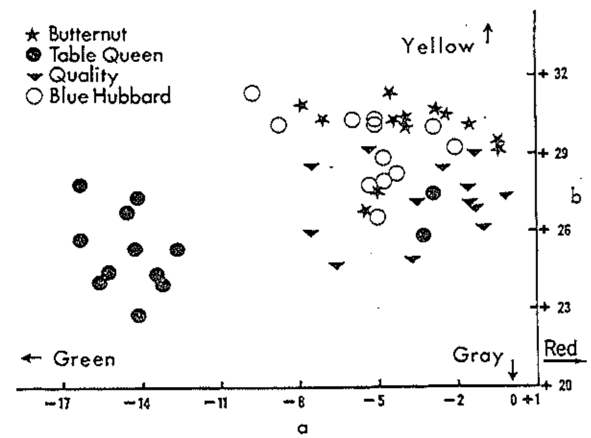

Fig. 1. Hunter Color and Color Difference meter *a* and *b* scale readings. Table Queen squash with the least red and yellow color component also had the poorest taste panel score. Butternut with the most yellow component also had the highest taste panel score.

Summary

The practice of curing winter stored squashes at high temperatures was not found to be beneficial and in the case of Table Queen was detrimental to both skin color and taste.

Higher weight losses occurred during early storage as a result of curing.

Squashes stored at 40° F for 3 weeks developed chilling injury while those stored at 50–60° did not develop this disorder.

There was very little correlation between taste panel scores and reducing sugar, total sugar, starch, and refractometer determinations.

Excellent correlations were obtained between color determinations of the cooked product and panel scores.

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Effect of Beet Yellows Virus on Rate of Growth and Yield in Spinach[1]

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Yellowing caused by beet yellows virus infection has produced severe loss in yield to spinach crops in the Salinas Valley of California. Fall infection with the beet yellows occasionally renders unmarketable the entire crop in an area. The principal factors determining yield reduction appear to be the per cent of plant population infected, stage of plant development at time of infection, and environmental conditions. Bennett (2) described the causal virus, transmission, host range, and symptoms of the disease on spinach. A review of earlier literature on beet yellows virus was included in Bennett's paper, and therefore is omitted here.

Spinach in the Salinas Valley may also be affected by another yellows disease, now known as beet western yellows (radish yellows), described by Duffus (4). The effect of this disease on spinach quality and yield has not been determined.

The purpose of this study was to determine the effect of beet yellows virus on the rate of growth and resulting yield of a spinach crop infected at various stages of plant development.

Materials and Methods

Two trials were conducted in commercial spinach fields in the Salinas Valley. Cultural practices in the trials were the same as the field in which the trial was located. Trial 1 was planted to variety Califlay December 3, 1956, with a multiple shoe planter (4 rows on each side of a 40-inch bed). This produced a population of approximately 204,500 plants per acre. The crop was harvested on March 28, 1957, 115 days after planting. Trial 2 was planted to variety Califlay February 2, 1960 and harvested in 83 days on April 25. Plants in this trial were thinned to a 3-inch spacing in the row, with 2 rows on a 40-inch bed. Both crops received a similar fertilizer program: pre-plant 15-8-0 (N, P_2O_5, K_2O) at 400 lbs/acre, first sidedressing about 45 days before harvest with 20-0-0 at 400 lbs/acre, and a second sidedressing 14 days before harvest with 20-0-0 at 200 lbs/acre. Applications totaled 180 lbs N/acre, 14 lbs P/acre, and zero K.

In trial 1, plants were inoculated at 2 stages of development, and in trial 2 at 1 stage. Table 1 gives inoculation dates, mean fresh weight per plant at inoculation, and per cent of potential growth at inoculation. The plants were inoculated with beet yellows virus, strain 5, by the method described by Bennett, *et al* (3). The plot area was sprayed with malathion 48 hours after each inoculation, and at 7-day intervals to minimize the chance of secondary spread of virus by the aphid vectors.

Each treatment, or plot, was a single bed 16 feet long. The plots

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