Reprinted from *J. Food Sci.*
52(4): 1030–1032

Effect of Curing on Sensory Properties and Carbohydrate Composition of Baked Sweet Potatoes

W. M. WALTER, JR.

ABSTRACT

In a two-year study, the flavor and texture profiles and carbohydrate composition of cured, baked 'Jewel' sweet potatoes were compared to baked, uncured 'Jewel' sweet potatoes. Curing increased the rate of production of flavor notes and only slightly influenced development of "moist" mouthfeel. Given sufficient time after harvest, baked, cured roots were indistinguishable from baked, uncured roots. Carbohydrate content was not a sensitive indicator of post-harvest treatment since no statistically significant differences were detected between cured and uncured roots.

INTRODUCTION

TO INCREASE the storage life of sweet potatoes, freshly harvested roots are cured at 29.5°C in 85–90% relative humidity (RH) for 4–7 days (Wilson et al., 1980). Optimum conditions for storing cured roots are 13–16°C at 80% RH. Carbohydrate conversions which occur during curing have been the subject of many research reports (Southern Cooperative Series, 1969; Edmund and Ammerman, 1971).

When sweet potatoes are baked, endogenous enzymes hydrolyze starch into maltose (Picha, 1985) and longer chain polysaccharides, resulting in a sweet taste and "moist" mouthfeel. Freshly harvested roots have low concentrations of amylolytic enzymes and sugars and, thus, when baked give a product with a "dry" mouthfeel and very little sweet taste (Walter et al., 1975). After curing, however, enzyme activity and sugars increase, and the baked root becomes sweet and moist. Data from many studies show that a baked, cured root is sweeter and more moist than a root baked immediately after harvest (Edmund and Ammerman, 1971).

Only limited data are available on the properties of roots placed directly into storage after harvest, as compared to roots cured before storage. It is not clear that the curing process is responsible or if the removal of the root from the leaves and petioles at harvest causes changes in root metabolism which result in the familiar increased sweetness and moist mouthfeel of the baked root. It may be that the elevated temperature of the curing process increases the rate at which the root responds to harvest-mediated metabolic changes.

The purpose of this study was to compare the sensory properties and carbohydrate concentrations of baked sweet potatoes prepared from roots placed in storage immediately after harvest to sensory properties and carbohydrate concentrations of roots cured before being placed in storage.

MATERIALS & METHODS

Sweet potatoes

Sweet potatoes (cv. 'Jewel') were grown at the Central Crops Experiment Station at Clayton, NC. In 1980 the roots were harvested in late October (150 days after transplant), and in 1981 roots were harvested in mid September (120 days after transplant). After each harvest, one group of roots was placed in a storage room (15°C, 65% RH). A second group of roots was placed under curing conditions (29.9°C, 75–85% RH). After 7 days, the cured roots were stored in the same room as the uncured roots. Samples of roots for baking were taken at harvest and at 9, 20, 37, and 68 days after harvest.

Author Walter is with the USDA-ARS and North Carolina Agricultural Research Service, Dept. of Food Science, North Carolina State Univ., Raleigh, NC 27695-7624.

Baking

Roots of fairly uniform shape and weight (ca. 250–300g) were selected for baking and grouped into three replicates with three roots per replicate. Roots were carefully washed, dried, wrapped in aluminum foil, and baked in a 204°C oven for 90 min. After baking, the interior flesh from each replicate was removed and passed through a collander (2 mm hole size). Replicate samples of collandered, baked, sweet potato puree were taken for sensory evaluation and chemical analysis.

Sensory evaluation

Flavor and texture profiles were assessed by a trained panel (Hamann et al., 1980). Scores for flavor and texture notes were based on a descriptive intensity scale that was converted to a 1 to 14 numerical scale for statistical analysis. A score of 1 = not detectable and a score of 14 = extremely intense. A single lot of canned sweet potatoes was used as the standard of comparison for both years. Sensory evaluations were performed at 10:00 am. to 11:00 a.m. At each sitting, the panelists were provided with four coded samples of freshly baked, collandered sweet potato puree and a collandered sample of the canned standard. The coded samples consisted of two replicates each of cured and uncured baked sweet potato. The flavor and texture notes had been defined and described earlier (Hamann et al., 1980). Individual scores and the consensus score for each character note were subjected to statistical analysis.

Chemical analyses

Moisture was measured on weighed purees by drying overnight at 65°C followed by 4 hr at 95°C in a forced draft oven. Alcohol-insoluble solids were measured on 25g samples of puree extracted three times with 100 mL volumes hot 80% ethanol followed by drying the residue at 95°C in a forced draft oven.

Sugars

Accurately weighed (ca. 1g) collandered puree was mixed with 3 mL water and held at 55°C for 2.5 hr. The mixture was transferred to a 50 mL volumetric flask and cooled. Ethanol (95%) was added and the solution was allowed to stand 24 hr. For analyses, contents were mixed, allowed to settle and aliquots removed. Sugar was measured using the phenol-sulfuric acid procedure of Dubois et al. (1956) and a series of glucose solutions as standards.

Starch was determined at the same time as sugar. Accurately weighed, 1g samples were mixed with 3 mL water and incubated at 55°C for 2.5 hr with 400 units of alpha-amylase (*Bacillus subtilis*, Sigma Chemical Co. St. Louis, MO). After incubation, the slurry was transferred to a 50 mL volumetric flask and handled as described for sugars. Solutions containing 400 units of alpha-amylase in 4 mL water served as controls. Starch was calculated by subtracting the sugar (no enzyme) and the enzyme sugar blank from the sugar of the enzyme-hydrolyzed puree. All values were transformed by appropriate factors into g/100g collandered puree.

Statistics

The data from sensory evaluation and chemical analyses were subjected to analysis of variance and general linear model (GLM) procedures (SAS, 1982).

RESULTS & DISCUSSION

Flavor notes

In the 1980 crop, scores for the three sweet notes in cured potatoes increased after curing and either decreased or remained constant (Table 1). At the same time, uncured root scores did not change significantly until the 20- or 37-day evaluation. The caramel note scores increased only for cured roots and only at the 20-day evaluation. Starch note scores declined below harvest scores at 68 days. Sweet aromatic and sweet basic scores for cured and uncured roots were indistinguishable at 37 days. Sweet after-taste cured and uncured scores were equal at 20 days. Caramel note scores for the two treatments were different only at 20 days, while starch note scores for cured and uncured treatments were not different.

For the 1981 crop, scores for caramel and the three sweet notes in both cured and uncured potatoes were higher than harvest scores at 9 days. By 37 days, starch note scores for both cured and uncured roots were less than at harvest scores. Flavor note scores for cured and uncured roots were identical at the 9-day evaluation. At 20 days, sweet basic, sweet aftertaste and caramel scores were higher for cured than for uncured roots. At 37 days, cured and uncured roots were indistinguishable by the panel. However, by 68 days, scores for the three sweet notes for uncured roots were greater for uncured roots than for cured roots.

The increase in scores for the three sweet notes demonstrated that sweet potato flavor improved after harvest. The only flavor note which declined was the starch flavor, reminiscent of the starch flavor of white potato. A decline in this note was expected because the starch content decreased with length of storage before baking (Table 2).

Our results show that sweet potatoes, whether cured at harvest or not, attain similar flavor note scores. In 1980, the cured roots were markedly sweeter and more flavorful until the 37-day evaluation, while in the 1981 crop, some flavor notes of cured roots surpassed uncured roots only at the 20-day evaluation.

Texture notes

For the 1980 study, cured scores at the 9-day test decreased from scores at harvest, except for first bite moistness (FBM) and ease of swallow (ES) which increased (Table 3). Uncured root scores at 9 days were higher than cured root scores at 9 days, except for FBM and ES scores which were lower. After 9 days, cured and uncured scores were not different. The general trend observed was that first bite denseness (FBD), mastication gumminess (MG), moisture absorption (MA), and chalkiness (CH) scores tended to decrease with time, while FBM and ES scores increased with time.

For 1981, with the exception of CH for the 9-, 20-, and 37-day tests, uncured roots had a lower score for FBD, MG, and MA. Uncured had higher scores than cured at 9, 20 and 37 days for FBM and higher scores at 20 and 37 days for ES. The general trend for 1981 scores was that highest scores were received for 0 time samples for FBD, MG, MA, and CH. The reverse occurred for FBM and ES.

Most previous research on sensorially perceived textural properties of baked sweet potatoes have dealt with a property called moistness or degree of moist mouthfeel. The texture profile used in this study contained six texture notes. A 'moist' or 'yam' type sweet potato is the most popular among U.S. consumers, and the texture notes all relate in some way to the degree of moist mouthfeel. From our data, increasing ES and FBM scores and decreasing FBD, MG, MA, and CH are indicative of the increasing moistness observed when roots are cured and stored prior to baking, as compared to roots baked at harvest.

In 1980 at 20 days, cured and uncured roots were scored similarly. In 1981, uncured roots appeared to be more moist through 68 days for some of the notes, although the texture notes, like the flavor notes, approached each other so that a similar baked product resulted. This study demonstrated that it is not necessary to cure sweet potatoes to obtain a high quality, baked product. Curing increased the rate of production of desirable flavor notes but did not strongly affect development of moist mouthfeel-type sensory attributes.

Chemical composition

Cured and uncured roots contained statistically indistinguishable amounts of sugars and alcohol-insoluble solids (AIS) at each test date (Table 2). Starch levels were also statistically the same at each test date for the 1980 study. In 1981, at 9 and 68 days cured root starch content was less than uncured root starch. In both years, starch content and AIS decreased as storage time of the raw roots increased, while sugar increased with increasing storage times. Hamann et al. (1980) reported that carbohydrate content was not a sensitive indicator of post-harvest treatment in that no statistically significant differences were noted between cured and uncured roots. Our data confirmed this conclusion.

To determine which attributes were correlated, Pearson product-moment correlation coefficients were calculated between all attributes separately for each set of cured and uncured data for both years of the study (SAS, 1982). Four correlation coefficients were obtained for each pair of attributes (cured, 1980; uncured, 1980; cured, 1981, uncured, 1981). All correlation coefficients were significant ($P \leq 0.05$) for the pairs listed: MA and FBM; MA and FBD; MA and ES (negative correlation); FBD and FBM (negative correlation); ES and FBM; ES and FBD (negative correlation); sweet basic and sweet aromatic (Table 4). Three of four correlation coefficients were significant ($P \leq 0.05$) for the pairs listed: MA and MG; FBM and CH (negative correlation); FBD and MG; ES and MG (negative correlation); ES and CH (negative); sweet after taste and sweet basic; AIS

Table 1—Flavor profile scores for baked 'Jewel' sweet potatoes[a]

Notes	Year of study	Harvest	Days after harvest: 9 Cured	9 Uncured	20 Cured	20 Uncured	37 Cured	37 Uncured	68 Cured	68 Uncured
Sweet aromatic[b]	1980	2.88^{D}	5.10^{A}	2.90^{D}	4.86^{A}	3.64^{DC}	4.36^{AB}	4.14^{ABC}	4.42^{AB}	4.17^{AB}
Sweet aromatic[b]	1981	3.50^{D}	4.79^{C}	4.93^{C}	5.06^{BC}	4.69^{C}	5.64^{AB}	5.86^{A}	4.76^{C}	6.04^{A}
Sweet basic[c]	1980	2.00^{E}	3.70^{AB}	1.80^{E}	3.93^{A}	2.36^{DE}	3.50^{ABC}	3.64^{ABC}	3.25^{BCD}	2.92^{CD}
Sweet basic[c]	1981	2.59^{E}	3.71^{CD}	3.71^{CD}	4.44^{AB}	3.75^{CD}	4.14^{BC}	4.21^{B}	3.57^{D}	4.86^{A}
Sweet after taste[d]	1980	2.13^{D}	3.10^{ABC}	2.10^{D}	4.07^{A}	3.00^{ABC}	3.14^{ABC}	2.64^{BCD}	3.25^{AB}	2.83^{BCD}
Sweet after taste[d]	1981	2.47^{D}	3.86^{ABC}	3.50^{C}	4.31^{AB}	3.38^{C}	3.79^{BC}	3.86^{ABC}	3.79^{BC}	4.43^{A}
Caramel[e]	1980	2.21^{B}	2.70^{B}	1.90^{B}	3.79^{A}	2.00^{B}	2.57^{B}	2.36^{B}	1.50^{B}	2.42^{B}
Caramel[e]	1981	1.56^{D}	3.07^{AB}	3.00^{AB}	3.38^{A}	2.50^{BC}	2.71^{ABC}	3.07^{AB}	2.86^{AB}	3.00^{AB}
Starch[f]	1980	3.71^{A}	3.00^{AB}	3.20^{AB}	3.00^{AB}	3.43^{A}	3.64^{A}	3.64^{A}	2.75^{B}	2.75^{B}
Starch[f]	1981	3.47^{A}	3.29^{ABC}	3.07^{ABCD}	3.19^{ABCD}	2.75^{BCD}	2.64^{CD}	2.57^{D}	2.57^{D}	2.57^{D}

[a] Scores from 1.0 = not detectable to 14 = very intense. Within each row, scores with same letter are not significantly different ($P \leq 0.05$).

[b] Sweet perceived through the olfactory epithelium in the nasal air passage.

[c] Sweet perceived on the taste buds of the tongue.

[d] Aromatic sweet as perceived through the olfactory epithelium up to 1 min after swallowing.

[e] Cooked sugar flavor.

[f] Resembling the typical flavor of white potato, an awareness of potato starch.

Table 2—Composition of baked 'Jewel' sweet potato[a]

	Years of study	Harvest	Days after harvest: 9 Cured	9 Uncured	20 Cured	20 Uncured	37 Cured	37 Uncured	68 Cured	68 Uncured
Alcohol-insoluble solids	1980	10.52^{A}	9.28^{BC}	9.37^{B}	8.99^{BCD}	8.35^{CDE}	7.47^{EF}	8.11^{DE}	6.44^{G}	7.10^{FG}
Alochol-insoluble solids	1981	11.36^{A}	9.89^{B}	9.89^{B}	9.43^{BC}	9.16^{CD}	8.63^{D}	8.72^{D}	8.96^{CD}	8.87^{CD}
Starch	1980	5.75^{A}	5.70^{A}	5.43^{A}	4.93^{AB}	5.22^{AB}	4.60^{AB}	4.15^{B}	2.50^{C}	1.44^{C}
Starch	1981	9.55^{A}	5.17^{D}	7.15^{BC}	6.47^{CD}	6.24^{CD}	7.89^{ABC}	8.30^{ABC}	5.18^{D}	6.91^{BC}
Sugars	1980	8.02^{B}	11.04^{A}	10.09^{AB}	10.52^{A}	10.30^{A}	9.10^{AB}	8.92^{AB}	10.14^{AB}	10.86^{A}
Sugars	1981	10.07^{E}	11.61^{D}	11.31^{D}	11.81^{BCD}	12.11^{BCD}	12.79^{BC}	12.77^{BC}	13.00^{B}	16.24^{A}

[a] Percent by weight of baked sample. In each row, numbers with the same letter are not significantly different ($P \leq 0.05$).

Table 3—Texture profile scores for baked 'Jewel' sweet potatoes[a]

Notes	Year of study	Harvest	Days after harvest: 9 Cured	9 Uncured	20 Cured	20 Uncured	37 Cured	37 Uncured	68 Cured	68 Uncured
First bite denseness[b]	1980	9.33^{A}	7.10^{BC}	8.90^{A}	7.79^{BC}	8.29^{B}	7.79^{BC}	6.57^{C}	5.00^{D}	5.17^{D}
First bite denseness[b]	1981	9.84^{A}	8.71^{BC}	7.86^{DEF}	8.75^{B}	7.81^{EF}	8.14^{CDE}	7.36^{F}	8.14^{CDE}	8.42^{BCE}
Mastication gumminess[c]	1980	8.75^{A}	5.50^{DE}	7.60^{B}	6.57^{CD}	7.14^{BC}	6.17^{CD}	5.92^{CD}	4.50^{E}	4.92^{E}
Mastication gumminess[c]	1981	10.31^{A}	8.14^{CD}	7.21^{EF}	7.88^{CD}	6.78^{F}	9.14^{B}	7.14^{EF}	7.79^{DE}	8.57^{BC}
Moisture absorption[d]	1980	9.63^{A}	7.20^{BC}	8.90^{B}	7.79^{B}	7.86^{B}	7.86^{B}	7.29^{BC}	5.58^{D}	6.41^{CD}
Moisture absorption[d]	1981	10.34^{A}	8.14^{C}	7.36^{D}	8.63^{BC}	7.56^{D}	8.50^{BC}	7.21^{D}	8.43^{C}	9.07^{B}
Chalkiness[e]	1980	5.63^{A}	2.70^{E}	5.00^{ABC}	3.86^{BCD}	4.14^{BCD}	4.00^{BCD}	3.93^{BCD}	3.67^{DE}	2.92^{DE}
Chalkiness[e]	1981	6.41^{A}	4.36^{BCD}	4.29^{BCD}	4.88^{B}	4.63^{B}	4.43^{BC}	4.29^{BCD}	3.21^{D}	3.29^{CD}
First bite moistness[f]	1980	6.67^{F}	9.00^{AB}	7.20^{DEF}	7.71^{CDE}	7.57^{CD}	8.14^{BC}	8.56^{AB}	9.25^{A}	8.92^{AB}
First bite moistness[f]	1981	4.59^{F}	7.07^{E}	8.00^{ABC}	6.94^{E}	8.31^{AB}	7.71^{BCD}	8.43^{A}	7.43^{CDE}	7.36^{DE}
Ease of swallow[g]	1980	9.54^{E}	11.20^{ABC}	9.80^{DE}	10.64^{BC}	10.21^{DE}	10.50^{CD}	11.07^{BC}	11.92^{A}	11.75^{AB}
Ease of swallow[g]	1981	7.81^{D}	9.36^{BC}	9.92^{AB}	9.06^{C}	10.13^{AB}	9.57^{BC}	10.43^{A}	9.64^{B}	9.50^{BC}

[a] Scores from 1.0 = not detectable to 14 = very intense. Within each row, scores with same letter are not significantly different ($P \leq 0.05$).
[b] Degree to which sample is solid or thick.
[c] Amount of energy required to disintegrate sample for swallowing.
[d] Amount of saliva needed to hydrate sample.
[e] Degree to which very fine sand-like particles are felt on the mouth surface, usually followed by a dry mouthfeel.
[f] Degree to which sample is perceived as wet to the palate.
[g] Effort required to swallow sample.

Table 4—Statistically significant Pearson product-moment correlations between flavor notes[a]

	Sweet aromatic: Year of study 1980	1981	Sweet basic: Year of study 1980	1981	Sweet after taste: Year of study 1980	1981
Sweet basic	0.68**/0.905*	0.909*/0.971**				
Sweet after taste			0.901*/NS	0.945*/0.997**		
Caramel			NS	0.898*/0.867*	NS	0.989*/0.883*

[a] Numbers on the left side of each cell are for cured roots; numbers on the right side are for uncured roots.
* = $P \leq 0.05$; ** = $P \leq 0.01$; NS indicates nonsignificant.

Table 5—Statistically significant Pearson product-moment correlation coefficients between texture notes[a]

	First bite denseness: Year of study 1980	1981	Mastication gumminess: Year of study 1980	1981	Moisture absorption: Year of study 1980	1981	Chalkiness: Year of study 1980	1981	First bite moistness: Year of study 1980	1981
Mastication gumminess	0.941*/ 0.976** 0.991**/	NS/ 0.959** 0.870*/	0.974**/	NS/						
Moisture absorption	0.955*	0.965**	0.982**	0.976**						
Chalkiness	NS/ 0.944*	0.916*/ NS	NS/ 0.972**	NS/ NS	NS/ 0.994**	NS/ NS				
First bite moistness	−0.908*/ −0.979**	−0.975**/ −0.985**	−0.976**/ −0.991**	NS/ −0.967**	−0.935*/ −0.975**	−0.944*/ −0.940*	−0.869*/ −0.951**	−0.876*/ NS		
Ease of swallow	−0.978**/ −0.999**	−0.978**/ −0.996**	−0.975** −0.983**	NS/ −0.962**	−0.991**/ −0.968**	−0.950**/ −0.948*	NS/ −0.956**	−0.933*/ NS	0.958**/ 0.986**	0.987**/ 0.995**

[a] Numbers on left side of each cell are for cured roots; numbers on right side are for uncured roots.
* = $P \leq 0.05$; ** = $P \leq 0.01$; NS = not significant.

and FBM (negative correlation); AIS and EOS (negative correlation). Two of four correlations were significant for those pairs listed: FBD and CH; ES and CH (negative correlation); caramel and sweet basic; caramel and sweet after taste; AIS and FBD; AIS and CH; sugars and CH (negative correlation); sugars and starchy (negative correlation); starch and MG.

Among the flavor notes (Table 4), only the sweet basic-sweet aromatic and the sweet basic-sweet after taste pairs were related in both years. For the texture notes (Table 5), MA, FBD, FBM, and ES were highly correlated, while MG and CH did not correlate as well. Apparently, either texture notes are more interrelated than are flavor notes, or the panelists are able to score the texture notes more consistently. Among the three carbohydrate fractions, AIS changes correlated best with texture note changes (Table 6) and starch correlated least with texture note changes. There was no correlation between any of the carbohydrate fractions and flavor notes. This is especially perplexing because the sugar content changes did not correlate with sweet basic or sweet after taste.

Table 6—Statistically significant Pearson product-moment correlation coefficients between texture notes, flavor notes and chemical composition[a]

	Alcohol-insoluble solids[c]		Sugars[c]		Starch content	
	Year of study		Year of study		Year of study	
	80	81	80	81	80	81
First bite moistness	NS/ −0.944*	−0.962*/ −0.868*				
Ease of swallow	NS/ −0.929*	−0.935*/ −0.883*				
First bite denseness	NS/ −0.913*	−0.979**/ NS				
Chalkiness	NS/ 0.992**	NS/ 0.875*	−0.927*/ NS	−0.915*/ NS		
Starch			NS/ −0.863*	−0.929*/ NS		
Mastication gumminess					NS/ 0.910*	0.941*/ NS

[a] Numbers on the left side of each cell are for cured roots; numbers on the right side are for uncured roots.

* = $P \leq 0.05$; ** = $P \leq 0.01$. NS = not significant.

[c] A dash in front of symbols indicates negative correlation.

REFERENCES

Dubois, M., Gilles, K.A., Hamilton, J.K., Rebert, P.A., and Smith, F. 1956. Colorimetric method for determination of sugars and related substances. Anal. Chem. 28: 350.

Edmund, J.B. and Ammerman, G.R. 1971. "Sweet Potatoes: Production, Processing, Marketing," p. 208. Avi Publishing Co., Westport, CT.

Hamann, D.D., Miller, N.C., and Purcell, A.E. 1980. Effects of curing on the flavor and texture of baked sweet potatoes. J. Food Sci. 45: 992.

Picha, D.H. 1985. HPLC determination of sugars in raw and baked sweet potatoes. J. Food Sci. 50: 1189.

SAS. 1982. "SAS User's Guide: Basics." SAS Institute Inc., Cary, NC.

Southern Cooperative Series. 1969. Thirty years of cooperative sweet potato research - 1939-1969. Bull. no. 159, p. 36.

Walter, W.M., Jr., Purcell, A.E., and Nelson, A.M. 1975. Effects of amylolytic enzymes on "moistness" and carbohydrate changes of baked sweet potato cultivars. J. Food Sci. 40: 793.

Wilson, L.G., Averre, C.W., Baird, J.V., Estes, E.A., Sorensen, K.A., Beasley, E.O., and Skroch, W.A. 1980. Growing and marketing quality sweet potatoes. N.C. State Univ. Exten. Publ. AG-09.

Ms received 10/3/86; revised 12/31/86; accepted 2/12/87.

Paper no. 10629 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh, NC 27695-7601.