

Comparison of Carbohydrate Components in Sweet Potatoes Baked by Convection Heating and Microwave Heating¹

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The carbohydrate fractions of sweet potatoes baked in a convection oven and in a microwave oven were compared. Samples baked in the microwave contained less total alcohol-soluble carbohydrates, reducing sugars, and dextrans and more starch than those cooked in the convection oven. Measurement of static stress of the samples suggested that samples cooked in the microwave oven would have a drier mouthfeel. As storage time increased, samples baked in the microwave oven became more dry, while those baked in the convection oven became more moist.

Previous studies have shown that sweet potatoes contain amylolytic enzymes that hydrolyze starch when the roots are cooked (Ikemiya and Deobald, 1966; Balls et al., 1957). Temperature of the tissues must reach about 80 °C before rapid hydrolysis begins (Hoover, 1967). Differences in the amount of α -amylase appear to account for differences in moistness or dryness of mouthfeel (Walter et al., 1975), and the amount of α -amylase varies with cultivar and storage history. The concentration of α -amylase in a given cultivar increases during curing and the first 12–16 weeks of storage. β -Amylase remains nearly constant.

Sweet potatoes baked in a microwave oven have a drier mouthfeel than those baked in a convection oven (Nelson, 1973). The rapid heating with a microwave might cause less variation in mouthfeel than is found with convection heating.

This study compares the carbohydrates of sweet potatoes cooked in a convection oven and in a microwave oven. Samples were taken after various periods of storage to determine the effect of storage on carbohydrate changes.

MATERIALS AND METHODS

Jewel sweet potatoes were grown at the North Carolina Agricultural Research Service Central Crops Research Station near Clayton, NC. Immediately after harvest, the roots were cured at 30 °C and near 100% humidity for 5 days. After curing, they were stored at 13 °C without controlled humidity. Roots were taken at harvest, after curing, and at designated times during storage.

At each sampling, six roots between 6.5 and 7.5 cm in diameter and 20–25 cm in length were selected. They were washed with warm water (ca. 27 °C), dried at room temperature for 30–60 min, and separated into three pairs on the basis of similarities in size and shape. One root of each pair was baked for 90 min at 190 °C in a preheated convection oven. The other member of each pair was cooked 3 min in a Litton Model 850 microwave oven at full power (6000 W). All roots were pierced before baking. The temperature at the center of the potatoes was measured by inserting a bimetallic dial thermometer. The temper-

ature for both microwave and convectional baking treatments was ~ 100 °C.

Sampling. After cooking, the roots were cooled and the edible portions scooped out. Root contents were mixed to form composite samples from which samples were drawn for analysis.

Samples for dry-matter determination consisted of 25 ± 1 g weighed to 0.01 g in a Petri dish. Samples for measurement of static yield (24 g) were weighed into 50-mL beakers. For other samples, the mashed sweet potato was placed in a 50-mL syringe, and measured amounts were forced through a 12-gauge cannula into appropriate containers. For total alcohol-soluble carbohydrates, duplicate 4-g samples were placed in 100-mL volumetric flasks with 17 mL of H₂O and made to volume with 100% ethanol, so the final ethanol concentration was 80%. Samples for dextrin and starch analyses (4 g in duplicate) were placed in 125-mL Erlenmeyer flasks with 96 mL of 83% ethanol, so the final ethanol concentration was 80%.

Analyses. Dry matter was determined as weight remaining after the samples had been heated to 105 °C for 16 h in a vented convection oven.

Static yield samples were mixed with 18 g of water to give a 4:3 (w/w) mixture of sweet potatoes and water. The samples were stirred to remove all lumps and allowed to stand for 2 h at room temperature, 23 ± 1 °C. A 1-cm-diameter, fluted, cylindrical rotor attached to a Brookefield Model RVT viscosimeter was immersed 2 cm into the puree. The rotor was started at 2.5 rpm, and the maximum scale deflection, which occurred as the rotor first began to turn, was recorded as static yield. Static yield is defined as the yield stress measured under static conditions and measures different flow characteristics from viscosity (DeMan, 1976). In previous unpublished laboratory studies, static yield was shown to correlate with viscosity and mouthfeel, as determined by Rao et al. (1975).

Total alcohol-soluble carbohydrates (TASC) and reducing sugars were determined after samples had equilibrated in 80% ethanol for 7 days or longer. TASC were determined by the phenol-sulfuric acid method of Dubois et al. (1956). Reducing sugars were determined with arsenomolybdate reagent (Hodge, 1961).

Dextrans were determined as material insoluble in 80% ethanol and soluble in 10% ethanol. Samples were allowed to equilibrate in 80% ethanol for more than 24 h. The alcohol was decanted, and samples were again made to volume with 80% ethanol and allowed to stand more than 24 h. After three such changes of 80% ethanol, the samples were covered with 10% ethanol and allowed to stand for at least 7 days. The supernatant was diluted 1:4 with 0.02 M (pH 7) phosphate buffer and treated with amylo-

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Table I. Carbohydrate Components and Rheological Properties of Sweet Potatoes Sampled at Different Dates and Baked by Two Methods: Microwave and Convection^{a,b}

sample	% total alcohol-sol carbohydrate		% reducing sugars		% dextrins		% starch		blue value of starch		static yield	
	micro	conv	micro	conv	micro	conv	micro	conv	micro	conv	micro	conv
at harvest	33.3 D	43.0 D	13.3 C	18.9 C	0.95 A	1.23 C	38.5 A	26.5 A	0.23 C	0.15 B	56.0 D	37.0 B
7 days (cured)	45.4 A	46.0 C	13.6 C	21.2 BC	0.42 B	2.89 C	31.7 BC	24.5 A	0.23 C	0.20 A	65.0 C	46.0 A
24 days	42.9 B	57.2 A	17.9 B	23.7 AB	0.94 A	10.46 A	34.2 B	5.7 C	0.24 C	0.11 C	60.0 D	27.0 D
36 days	39.3 C	53.1 B	21.5 A	26.2 A	0.90 A	10.23 A	29.4 C	9.1 B	0.32 B	0.12 C	69.0 B	33.0 C
42 days	40.3 C	54.8 B	21.0 A	27.5 A	0.81 A	8.17 B	40.4 A	11.8 B	0.32 B	0.18 AB	80.0 A	35.0 BC
63 days	34.4 D	55.1 AB	6.1 D	22.7 B	0.81 A	8.61 B	36.6 A	5.8 C	0.40 A	0.11C	83.0 A	28.0 D

^a Dry-weight basis. ^b Numbers in the same column with different letters are statistically different ($P \leq 0.05$).

Table II. Regression Equations for Changes in Carbohydrate Components and Rheological Properties of Baked Sweet Potatoes Caused by Length of Storage^a

component	microwave		convection	
	A	B	A	B
TASC ^b	0.058	40.8	0.158	47.3
reducing sugars	0.046	16.8	0.076	21.3
dextrins	0.001	0.78	0.103	4.17
starch	0.024	34.5	-0.280	21.5
blue value	0.00287 ^c	0.207	-0.000675	0.160
static yield	0.420 ^c	57.7	-0.152	38.5

^a Regression equation: % component = $A \times \text{days} + B$. ^b Total alcohol-soluble carbohydrates. ^c Significant at the 0.05 level. Others are not significant.

glucosidase (Dekker and Richards, 1971). Glucose was measured by the glucose oxidase reaction. The residue remaining after dextrin extraction was dried with 100% ethanol, and lipids were extracted with a 1:1 mixture of diethyl ether-methanol. Starch was removed from the residue by equilibrating with 50 mL of dimethyl sulfoxide (DMSO) for 24 h and twice with 25 mL of DMSO for 24 h. The DMSO extracts were combined, made to 100 mL with DMSO, and added to 200 mL of absolute ethanol. After 24 h, the precipitated starch was recovered by filtration through a Whatman No. 1 filter, dried, and weighed. A sample of the starch, 0.1000 g, was dissolved by warming to 40 °C in 1.0 N NaOH. Blue value was determined as previously described (Walter et al., 1976).

RESULTS AND DISCUSSION

The carbohydrate composition of sweet potatoes baked in the microwave oven was similar to that of the dry types (low α -amylase) studied by Walter et al. (1975; Table I). Apparently, microwave cooking was too rapid to allow significant starch degradation by the α -amylase. It was previously shown that α -amylase activity increased during storage (Ikemiya and Deobald, 1966; Walter et al., 1975). However, for microwave-cooked roots, TASC, reducing sugars, dextrins, and starch did not change linearly with storage time, while starch blue value and pure α -D-glucose static yield were positively correlated with storage time (Table II). An increase in blue value is caused by an increase in the average linear chain length of the starch. It is unlikely that the relative amounts of linear and branched components changed during the postharvest period encompassed by this study. A possible explanation is that due to a combination of the postharvest α -amylase activity increase and heating rate peculiar to the microwave oven the branched component (amylopectin) was degraded to expose additional linear regions that participated in iodine binding.

For sweet potatoes baked in the convection oven, increases were observed in alcohol-soluble carbohydrates, reducing sugars, and dextrins. Simultaneously, decreases were noted for percent starch, blue value, and static yield

Table III. Correlation Coefficients Relating Function of Component on Static Yield

component	correln coeff	component	correln coeff
TASC ^a	0.817 ^b	starch	0.880 ^b
reducing sugars	0.652	blue value	0.964 ^b
dextrins	0.120	starch \times blue value	0.978 ^b

^a Total alcohol-soluble carbohydrates. ^b Significant at the 0.05 level. Others are not significant.

(Table I). The only significant linear trends from harvest until 63 days of storage were the changes in blue value and static yield of roots cooked by microwave heating. Significant changes occurred for all other variables during the first 24 days after harvest. Comparison of the values for microwave and convectionally baked sweet potatoes indicated that those factors associated with a moist sweet potato (i.e., high sugar and dextrin content and decreased starch content and static yield) are lower in the microwave-baked roots than in the convection-oven-baked roots. Static yield increases observed for microwave-baked sweet potatoes indicated that intermolecular binding of the baked material increased. Enhanced intermolecular binding is usually caused by a rise in macromolecular size or effective concentration. It is possible that the trend observed with the microwave-cooked material is caused by the interaction of rapid heating and compositional changes in macromolecules such as pectins and hemicelluloses during postharvest storage.

Static yield was correlated with TASC, starch, and blue value (Table III). The correlations were similar to those obtained by Walter et al. (1975, 1976) between the carbohydrates and viscosity. The product of percent starch and blue value was more closely correlated with static yield than either value alone. On the basis of previous correlations between starch and mouthfeel, it appears that static yield may be a useful means of predicting mouthfeel.

We conclude from these studies that microwave cooking at full power will yield a consistently dry type of baked sweet potato. It is possible that a schedule of cooking could be devised such that the sweet potato would be heated to 80–85 °C, maintained at that temperature for about 7 min, and then finish-cooked at full power. Such a regime could result in a microwave-baked root of quality similar to that prepared by convection baking.

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