EFFECTS OF PUREE PROCESSING METHODS ON THE TEXTURAL CHARACTERISTICS OF AN ALGINATE-TEXTURIZED SWEET POTATO PRODUCT[1]

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Accepted for Publication November 1, 1998

ABSTRACT

The objective was to determine the effect of sweet potato (SP) puree preparation methods on the properties of texturized SP products. The treatments were separated into two main types in which sliced SPs were cooked prior to puree preparation, or purees were prepared by grinding raw roots, followed by heat processing using steam injection. Purees from each treatment were texturized into cylinders 12.7 cm long and 5.5 cm in diameter, using an alginate-calcium system, and frozen. We found that cooked purees prepared by steam injection of raw purees had higher viscosities than did purees made from cooked SP. Texture Profile Analysis (TPA) revealed that texturized product made from SP cooked before puree preparation was the most fracturable and least springy of the texturized products. Sensory panelists did not express a preference for texturized product from any of the treatments, but 23% of the panelists noted a grainy texture and/or raw root aroma in products prepared by steam injection of raw purees. In view of these observations and the fact that puree preparation from cooked SP is the simplest process, this process appears to be the best for this type of texturized SP product.

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Journal of Food Quality 22 (1999) 631–640.

INTRODUCTION

Restructuring sweet potato (SP) puree into various shapes and sizes has been shown to be an effective method to control product textural characteristics, and to utilize virtually all harvested roots (Truong and Walter 1994). This technology has been used to develop model products such as a simulated baked SP (Truong *et al.* 1995) and a French-fry type SP product. The concentration and molecular size of endogenous starch plays an important role in controlling the texture of SP products (Walter and Schwartz 1993). Moreover, the fate of this important component is dependent upon the cooking temperature and activities of the SP amylolytic enzymes, alpha- and beta-amylase (Walter *et al.* 1975; Shen and Sterling 1981). Puree preparation methods can exert a significant effect on starch hydrolysis and, thus, influence the sweetness and texture of pureed SP products. However, the effect of puree preparation methods on the textural properties of texturized products made from those purees is not known. The objective of this study was to determine if textural and sensory properties of texturized products were affected by puree preparation methods.

MATERIALS AND METHODS

Puree Preparation

Five treatments (Fig. 1) were used to prepare cooked purees from lye-peeled roots of Jewel cultivar SP which had been stored for 10 months after harvest. All purees were prepared by grinding raw or cooked SP in a hammer mill to pass through a 0.076 cm (diameter) screen. The treatments were as follows: T1 - steam injection (SI) of raw puree to 110C in order to inactivate endogenous amylases; T2 - SI of raw puree at 110C, cool to room temperature, mix with 20% (w/w) raw SP puree to provide active amylases for starch hydrolysis, SI of the mixture to 70C, hold for 20 min, and SI to 110C; T3 - SI of raw puree to 70C to gelatinize the starch and permit endogenous amylolytic enzymes to hydrolyze starch, hold for 20 min, SI to 110C. For T4, peeled, sliced SP were cooked at 100C in a Thermascrew Cooker (Rietz Manufacturing Co., West Chester, PA) for 20 min and pureed. This treatment was the only one comprised entirely of SPs cooked before pureeing. For T5, batches consisting of 800 g of the cooked pureed material mixed with 200 g raw SP puree were steam injected to 70C, held for 20 min, and steam injected to 110C. This treatment was included to determine if further starch hydrolysis could occur when additional endogenous amylolytic enzymes were added and, thereby, modify puree or product properties.

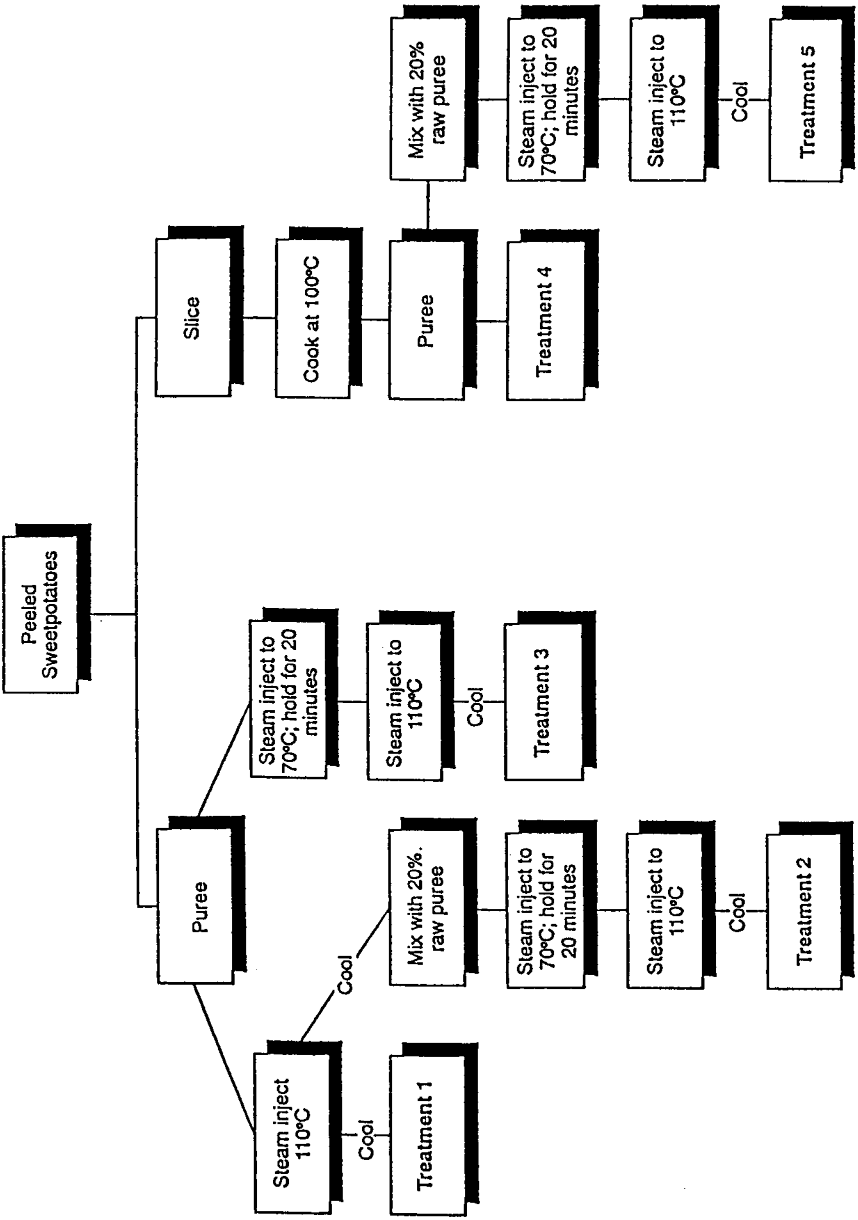

FIG. 1. SWEET POTATO PUREE PREPARATION FLOW SHEET

Texturization

Cooked purees from the five treatments described above were texturized using an alginate-calcium system as follows. Mix 1366 g of treated puree with a mixture containing 3.07 g of trisodium phosphate and 20 g sucrose. After thorough mixing, add a mixture containing 6 g of alginate (Kelco Corp.) and 70 g of sucrose and again thoroughly mix. Finally, add 4.5 g of $CaCl_2 \cdot 2H_2O$ in 30 mL of water and thoroughly mix. Extrude the blended mixture into 5.5 cm diameter sausage casings into "logs" 12.7 cm in length, cure overnight at 4C, and hold at -20C until needed.

Analysis

Puree Composition. Dry matter, alcohol-insoluble solids (AIS), starch and sugars of the purees, and the texturized products were measured as described previously (Walter and Schwartz 1993).

Puree Rheology. Viscosities of purees from each of the treatments were measured at 25C using a Bohlin VOR Rheometer (Bohlin Reologi AB, Lund, Sweden). The CP 5/30 cone and plate measuring system was used and the instrument operated in the oscillatory mode at a frequency sweep from 0.002 to 20 Hz over a 635 sec time period using at 25C. From the data besides the viscosity, the following parameters were calculated at frequencies of 0.05, 1, and 20 Hz; 1 - storage modulus (G′); 2 - loss modulus (G″).

Texture Profile Analysis (TPA) and Sensory Evaluation. To prepare the texturized products for testing, the sausage casings were removed and the "logs" of texturized product were cooked in a gas convection oven for 15 min at 204C before subjecting to instrumental texture profile analysis (TPA) and sensory evaluation.

TPA parameters of the texturized samples were measured at 25C using a TA.XT2 Texture Analyzer (Texture Technologies Corp., Scarsdale, NY; Stable Microsystems, Hoselmere, Surrey, UK). TPA parameters, namely fracturability, hardness, cohesiveness, and gumminess, were determined as described by Bourne (1978). Springiness was calculated as a proportion of the compression distance recovered between the first and second compression.

For sensory evaluation, panelists (n = 31) situated in individual booths illuminated with fluorescent light were served five randomly coded cylindrical samples each of which was 1.5 cm in diameter and 3 cm long. Panelists were asked to rate samples for overall acceptability on a 9-point hedonic scale, where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely. They also were asked to comment on their impressions of the samples. Two replications of the sensory evaluation were conducted.

Statistical Analysis. A completely randomized design was used, with two replicates per treatment. Data were analyzed using the General Linear Models Procedure of the Statistical Analysis System (SAS Institute 1994). Analysis of variance and means separations were calculated by the General Linear Models Procedure. Differences ($P \leq 0.05$) between treatment variables were evaluated by the Least Square Means Procedures.

RESULTS AND DISCUSSION

Cooking and pureeing of the SP roots resulted in decreased dry matter, AIS and starch concentrations (Table 1). As expected, starch hydrolysis was lowest for puree from T1 (52%), compared with ca. 81.8-77.7% for the others. The reason for lower hydrolysis is that SI to 110C instantaneously increases the puree temperature above the inactivation temperatures for endogenous amylolytic enzymes (alpha- and beta-amylase) Thus, they are able to interact with the gelatinized starch for only a very short period of time before being inactivated (Walter and Purcell 1976). In addition, lower starch hydrolysis is reflected by lower total sugar concentrations for T1, as compared with the other treatments. Purees prepared by the other treatments (T2 through T5) had similar sugar and starch concentrations.

TABLE 1.

COMPOSITIONAL ANALYSIS OF SWEETPOTATO PUREES[a] PREPARED BY SEVERAL PROCESSING TREATMENTS[b]

Treatment[c]	Dry Matter (%)	AIS (% of Fresh Weight	Total Sugars (% of Fresh Weight)	Starch (% of Fresh Weight)	Starch Hydrolysis (%)
Raw Sweetpotatoes	22.20a	13.53a	6.88c	9.36a	0
T1	16.43b	7.61b	8.21b	4.47b	52.0b
T2	17.38b	5.76b	11.72a	1.69c	81.8a
T3	16.88b	5.62b	10.62a	1.97c	78.8a
T4	18.35b	5.79b	11.47a	2.08c	77.7a
T5	16.91b	5.96b	10.78a	1.74c	81.3a

[a] All purees were ground to a particle size of <0.076 cm (diameter).

[b] Means in the same column with different letters are significantly different ($P \leq 0.05$).

[c] For treatment identity, refer to Fig. 1.

All purees demonstrated shear thinning (pseudoplastic) behavior, as indicated by decreasing complex viscosities with increasing oscillation frequencies (i.e. increased shear rates; Table 2). For oscillation frequencies of 0.2 hertz (Hz) and greater, complex viscosities of the treated purees prepared by steam injecting raw purees (T1, T2, T3) tended to be greater than were the complex viscosities of purees prepared from cooked SP slices. Treatment T5, however, was the only puree which had a statistically significant lower complex viscosity. This indicates that cooking SP slices before pureeing more thoroughly disrupts tissue and organelle organization than does SI of the pureed material. A possible explanation is as follows. When raw SP is pureed and rapidly cooked or pureed, mixed with 20% (w/w) raw puree, held at 70C to allow starch hydrolysis to occur, and then rapidly cooked (treatments T1, T2 and T3), cell walls are less degraded than when SP is more slowly cooked and then pureed (treatments T4 and T5). The less disrupted tissue has a higher complex viscosity because the particles (cells, swollen starch granules, etc.) occupy more space within the matrix and, during viscosity measurement, are forced to flow past one another. In the process of flow, particles frequently encounter one another, thus retarding flow and increasing the viscosity. Analogous behavior is observed with starch pasting curves obtained with a Brabender ViscoAmylograph (Kruger and Murray 1976). Apparently starches were equally degraded in all treatments except T1. Our procedure, however, will not detect the extent of starch hydrolysis. Thus, differences in the size of starch hydrolysis products may also have influenced viscosities of the purees.

Examination of the treated purees' storage moduli (G′) and loss moduli (G″) at several frequencies revealed that, except for T1 at 0.05 Hz, values for G″ were greater than those for G′ (Table 3), indicating that the purees had more viscous than elastic character (Hansen *et al.* 1990). In addition, T1 puree had a greater G′ value than did the other treatments, indicating that it was more elastic than the other treatments. This is possibly caused by undisrupted tissue acting as a filler in the starch matrix.

Purees from treatments T1-T5 were texturized into product "logs" using the alginate-calcium system and instrumental TPA parameters measured (Table 4). Although there were few cases in which the TPA parameters were statistically different between treatments, it is possible to speculate on some trends. Logs from puree T1 were among the least fracturable, the least hard, the most adhesive and cohesive, and the springiest. These rheological characteristics could be due to the fact that puree from T1 had a higher starch content than any of the other treatments. On the other hand, product made from T4 puree was the only product which did not contain any puree prepared by grinding raw SP. This product tended to be among the most fracturable, the hardest, the least adhesive, cohesive, and springy. Purees T2, T3, and T5 contained varying amounts of material which had been ground in a hammer mill before cooking.

TABLE 2.

COMPLEX VISCOSITIES[a] OF SWEETPOTATO PUREES[b] MEASURED AT SEVERAL OSCILLATION FREQUENCIES[c]

	Frequency (Hz)				
Treatment[d]	0.05	0.2	1.0	5.0	20.0
T1	552.3a	228.5a	71.8a	23.6a	9.3a
T2	630.8a	260.7a	66.5a	19.9a	6.5a
T3	638.0a	224.5a	70.2a	23.7a	8.45a
T4	423.8a	182.8ab	57.5ab	18.6ab	4.75ab
T5	254.0b	128.8b	41.8b	13.6b	3.6b

[a] Pascal-seconds = Pa s.
[b] All purees were ground to a particle size of <0.076 cm (diameter); means in the same column with different letters are significantly different ($P \leq 0.05$).
[c] Oscillation frequencies are given in Hertz (Hz).
[d] For treatment identity, refer to Fig. 1.

Although some differences in TPA parameters were detected (Table 4), sensory panelists did not find product made from any of the treated purees to be more acceptable. Scores ranged from 6.1 to 6.4. It is possible that human subjects do not consider texture differences detected by the TPA sufficient to impact acceptance. However, 23% of the sensory panelists noted a "grainy texture" and "raw root aroma" in products from T1, T2, T3, and T5. Since T4 is the simplest process and sensory panelists noted texture and aroma discrepancies in products made from the other treatments, we recommend that T4 is the best process for making this type of texturized SP product.

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TABLE 3.

STORAGE AND LOSS MODULI OF SWEETPOTATO PUREES[a] MEASURED AT SEVERAL OSCILLATION FREQUENCIES

	Storage Modulus, G′ (Pascals)			Loss Modulus, G″ (Pascals)		
	Frequency (Hz)			Frequency (Hz)		
Treatment[b]	0.05	1.0	20	0.05	1.0	20
T1	131.8a	238.5a	646a	132.0ab	382.5a	966.0ab
T2	89.6b	97.2b	238.8b	239.0a	406.0ab	783.3b
T3	55.8bc	97.5b	283.3b	191.0ab	430.0ab	1023.0ab
T4	47.7bc	80.8b	236.8b	121.8ab	351.5ab	552.5c
T5	29.1c	58.2b	171.5b	66.1b	255.5b	414.8c

[a] All pureees were ground to a particle size of <0.76 cm (diameter); means in the same column with different letters are significantly different ($P \leq 0.05$).

[b] For treatment identity, refer to Fig. 1.

TABLE 4.

INSTRUMENTAL TEXTURE PROFILE ANALYSIS (TPA) OF ALGINATE-TEXTURIZED PRODUCT MADE FROM TREATED SWEETPOTATO PUREES[a]

Treatment	Fraturability (Newtons)	Hardness (Newtons)	Adhesiveness (mj)[c]	Cohesiveness[d]	Springiness[d]	Gumminess (Newtons)
T1	2.25c	5.12c	0.0036a	0.19a	0.31a	0.97a
T2	3.60b	7.59ab	0.0013b	0.13b	0.25b	0.99a
T3	2.57bc	5.34c	0.0019b	0.16a	0.25b	0.87a
T4	4.50a	8.26ab	0.0009b	0.11b	0.20c	0.95a
T5	3.27b	6.10bc	0.0010b	0.13b	0.24b	0.81a

[a] All purees were ground to a particle size of <0.76 cm (diameter); means in the same column with different letters are significantly different ($P \leq 0.05$).
[b] For treatment identity, refer to Fig. 1.
[c] millijouls = mj
[d] These parameters are dimensionless

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