Physical and Sensory Properties of Sweetpotato Puree Texturized with Cellulose Derivatives

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ABSTRACT

We evaluated the physical and sensory characteristics of restructured sweetpotato puree texturized with methylcellulose (MC) or methylhydroxypropylcellulose (MHPC). Samples were studied by instrumental texture profile (TPA), dynamic rheometric and sensory analyses, and scanning electron microscopy. Gelation of the gum-puree mixtures gave maximal values of the storage modulus (G') at 60–70°C. The TPA curves measured at 60°C for the 0.50% MC or MHPC sample were similar to those of baked sweet potatoes (control). A texture profile panel rated the 60°C samples of the 0.25–0.50% MC or MHPC product as nearly equal to baked roots for several texture notes. An untrained acceptability panel scored the 0.25% MC and MHPC samples significantly higher in flavor and overall acceptability than baked roots.

Key Words: sweetpotato, restructured tubers, gelation, elastic rigidity cellulose derivatives

INTRODUCTION

SWEETPOTATOES are an economical and healthful food crop containing high beta-carotene and substantial amounts of ascorbic acid and minerals (Woolfe, 1992). Yet, limited sweetpotato production is utilized for processing of canned roots, frozen patties, and baby food (Bouwkamp, 1985; Collins and Walter, 1992). The main market form of sweetpotatoes is fresh roots. They, in most cases, are cooked at home. Since home preparation is usually lengthy (e.g. 80–90 min at 204°C for baked sweetpotatoes), many prospective consumers, because of the time required will not use the product. Moreover, the quality of fresh market sweetpotatoes can vary due to cultivar differences, growing conditions, and post-harvest handling practices (Walter, 1987). The per capita annual consumption of sweetpotatoes has declined from ≈12kg in the 1930s to only about 2.25 kg in 1988 (Collins and Walter, 1992).

For commercial success, a processed sweetpotato product must be of consistent quality regardless of raw material. One way to control the taste, texture, and color may be to restructure sweetpotato puree. Since the form that many sweetpotato consumers prefer is the baked sweetpotato, it seemed feasible to develop a similar model restructured system. Food ingredients with various functionalities, make possible a wide range of characteristics for food products (Hannigan, 1983; Glicksman, 1984; Mandigo, 1986).

Cellulose derivatives such as carboxymethylcellulose (CMC), microcrystalline cellulose (MCC), methylcellulose (MC), and methylhydroxypropylcellulose (MHPC) have been used as texture modifiers, thickeners, binders, emulsifiers, stabilizers, water retention aids, etc. (Grover, 1982; Dziezak, 1991). Incorporation of 6.3% MCC-CMC blend with 6.7% tapioca and corn starch improved the sensory characteristics of frozen sweetpotato patties (Pak, 1982). The MC and MHPC gums improved the texture and crumb structure of baked products (Bell, 1990). MHPC can reduce cholesterol levels in humans (Anonymous, 1993). Therefore, the use of MHPC in foods might increase their healthfulness.

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Our objective was to evaluate the physicochemical and sensory properties of sweetpotato puree restructured with cellulose derivatives and to compare the restructured products with traditionally baked sweetpotatoes.

MATERIALS & METHODS

Preparation of puree

Jewel cultivar sweetpotatoes, harvested in October 1992, were cured and stored at 13–16°C and 80–90% relative humidity (RH) prior to use. Roots were washed, peeled by immersion in boiling solution (104°C) of 5.5% NaOH for 4 min, and thoroughly washed in a rotary reel-sprayed washer to remove separated tissue and lye residue. Peeled roots were hand-trimmed and cut into slices (0.95 cm thick) (Louis Allis Co. Slicer, Milwaukee, WI). The slices were steam-cooked for 20 min in a thermoscrew cooker (Rietz Manufacturing Co., Santa Rosa, CA) and comminuted in a hammer mill (model D, Fitzpatrick Co., Chicago, IL) fitted with a 0.15 cm screen. The puree was filled into polyethylene bags, frozen, and stored at −20°C until used in products. For the two replications, two batches of puree were prepared from the stored roots. The puree of baked sweetpotatoes was prepared as previously described (Walter, 1987).

Restructured sweetpotato

Restructured baked sweetpotato was made by mixing sweetpotato puree with sucrose and cellulose gums in an electronic chopper (model UMC5, Stephan Co., West Germany) for 3 min at 1800 rpm with interval interruptions to scrape the material adhered on the sides of the bowl. Sucrose was added at 6% of total weight of the mix. Concentrations of added hydrocolloid materials were 0.25, 0.50, 0.75, and 1% (w/w) MC (Benecel M043, lot 7107), or MHPC (Benecel MP874, lot 5828) obtained from Aqualon Gum Company (Wilmington, DE). Benecel M043 and MP874 had 27.5-31.5% and 19-24% methoxyl substitution, and the viscosities of 2% gum solutions were about 4000 and 70000 mPas, respectively (Aqualon, 1992). The blended mixture was placed in a manual sausage stuffer and extruded into 5.5 cm diameter sausage casings to form rolls about 10 cm long. The rolls were then frozen and stored at −20°C.

Sensory evaluation

Before baking, sausage casings of the frozen formulated sweetpotatoes were removed. Unthawed samples were baked in a conventional oven at 204°C for 15 min, immediately cut into 2.5 cm thick slices perpendicular to the long axis, each slice placed in ≈120 mL glass jars, and kept at 70°C until served. The elapsed time between sample preparation and evaluation was about 1–2 hr. The product texture was stable under these conditions. The temperature of the samples was 55–65°C when evaluated by panelists. For baked sweetpotato roots, stored roots of fairly uniform shape and size (ca. 6.5–7.5 cm in diameter) were selected, carefully washed, air-dried, wrapped in aluminum foil, and baked at 204°C for 90 min. The samples for sensory evaluation were prepared as described for the restructured sweetpotatoes and only the middle portion of the roots were used.

Sensory texture profiles were assessed by a 6-member panel previously trained in profile methods of descriptive texture analysis (Brandt et al., 1963) for various foods, including sweetpotato. The panelists were trained specifically on baked sweetpotatoes following established guidelines (Civille and Szczesniak, 1973) in two 3-hr training sessions on two consecutive days. The panel established texture notes and definitions (Table 1). Scores for texture notes were based on a 14-point descriptive

Table 1—Texture profile panel notes, procedure, and description for regular and restructured baked sweetpotatoes

— First bite:	
Compress the sample between the tongue and the palate, evaluate for:	*Firmness* – amount of force necessary to compress the sample fully between the tongue and the palate
	Adhesiveness to palate – the force required to remove the compressed sample from the palate with the tongue
	Denseness – degree to which the sample is solid, compactness of the cross section
	Smoothness – degree to which the sample is free from particles or surface unevenness, such as holes
	Moistness – degree to which the sample is moist
— Mastication:	
Chew and evaluate for:	*Chewiness (also called gumminess)* – number of chews required to prepare the sample for swallowing when chewing at a constant rate of one chew per second
	Adhesiveness of the mass – degree to which the sample adheres or sticks to any surface of the mouth such as teeth, gums, palate
	Fibers – amount of any stringy fibers perceived
— Swallow/Residual:	
At the time of and immediately after swallow, evaluate for:	*Ease of swallow* – ease with which the sample is gathered up and swallowed
	Mouth coating – amount of sample remaining in the mouth after swallow
	Fibers – amount of stringy fibers perceived
	Chalkiness – degree to which the mouth feels chalky, like raw potato, very fine particles, if present, often perceived on the roof of the mouth.

intensity scale (Caul, 1957) that was converted to a 1 to 14 numerical scale for statistical analysis, with 1 = not detectable and 14 = extremely intense. At each session, panelists evaluated five coded samples in random order. A sample of baked sweetpotato roots, prepared as described, was used as control and reference standard.

Samples of selected mixtures and baked roots were subjected to an acceptability test by a 30-member, untrained panel consisting of staff and graduate students from the Dept. of Food Science at North Carolina State Univ. Samples were presented in the same manner as to the trained panel. Panelists were asked to simultaneously evaluate five samples in a random order for color, flavor, texture, and overall acceptability on a hedonic scale of 9 points (9 = like extremely, 1 = dislike extremely). All panel sessions were conducted in a sensory panel room with partitioned booths and fluorescent lights.

Physical measurements

Instrumental texture profile parameters were determined at 25 and 60°C following the Texture Profile Analysis (TPA) procedure. Fracturability, hardness, adhesiveness, cohesiveness, and gumminess were determined as described by Bourne (1978). Springiness is the recovered height of the sample after the compressive force is removed (Bourne, 1978), and was calculated as the proportion of the compression distance recovered between the first and second compressions (Montejano et al., 1985). The baked samples were prepared as described and divided into 2 parts. Half was cooled to room temperature for several hours and the other half enclosed in aluminum foil and equilibrated in a 70°C oven. For measurements at 25°C, the cooled samples were cut into 2 cm cubes (about 8–9g). Cubes were weighed and then subjected to 75% double compression and relaxation using an Instron Universal Testing Machine (UTM; model 1122, Instron Inc., Canton, MA) fitted with a 50-kg load cell with a plunger having a 5.7-cm diameter compression anvil. Measurements were performed with a crosshead speed of 10 cm/min and a chart speed of 20 cm/min. For measurements at 60°C, the compression cell of the Instron was housed in an environmental chamber (Standard Environmental Systems Inc., Totowe, NJ) set at 60°C and 60% RH. The hot samples were quickly cut into 2 cm cubes, weighed, placed on the compression cell, and allowed to equilibrate for 10 min before starting the measurements. At least four measurements were taken for each sample of the restructured sweetpotatoes. Ten baked roots of similar size and shape were used, and a sample was taken from the middle part of each root. Data were expressed in units of texture profile parameters per 10g sample.

A Bohlin VOR Rheometer (Bohlin Reologi AB, Lund, Sweden) with a concentric-cylinder-fixed bob and rotating-cup measuring cell (C 25) attached to a 103.33 gcm torsion bar was used in thermal scannings of the formed gels. All measurements were conducted in oscillation at a frequency of 0.05 Hz and a strain of about 1%. The temperature was raised from 25 to 95°C, held at 95°C for 15 min, and lowered to 25°C. The heating and cooling rates were set at 1°C/min. Hunter color values (L, a, b) were determined from reflectance measurements using a Spectrogard color system (Pacific Scientific, Silver Spring, MD) with daylight illuminant.

Microscopic examination

Microstructure was examined with a scanning electron microscope (SEM). Samples were baked as described and immediately fixed in 6% glutaraldehyde in 0.2M Na cacodylate buffer at pH 7.2 at 4°C, dehydrated, critical-point-dried, gold-coated, and photographed at various magnifications in an ETEC Autoscan microscope (Walter and Schadel, 1982).

Statistical analysis

Data were evaluated by analysis of variance and means separations calculated by the General Linear Models Procedure of the Statistical Analysis System (SAS Institute, Inc., 1988). Differences (<0.05) between treatment variables were evaluated by Least Square Means Procedures. Dunnett' T test was used to compare the means of TPA values of the formulations and the control (SAS Institute, Inc., 1988).

RESULTS & DISCUSSION

Restructured products and rheological properties

Preliminary studies indicated that the total content of sugars (fructose, glucose, sucrose, and maltose) in the puree of Jewel cultivar was 13.9%, which was lower by 3.2% than that of baked roots. This is due to more rapid inactivation of amylolytic enzymes during steaming of sweetpotato slices in puree processing, resulting in a lesser starch conversion into sugars (Walter and Schwartz, 1993). Sucrose was, therefore, added to the sweetpotato puree to attain the sweetness usually preferred for baked sweetpotatoes. Sucrose addition did not significantly change puree apparent viscosity. The puree containing added sucrose is referred to as the base puree.

As shown in the thermogram of the base puree (Fig. 1), the storage modulus (G') declined slightly during heating from 25 to 70°C and decreased sharply above 70°C. The phase angle (δ) was relatively constant (data not shown), indicating that there was no gel to sol phase change. The thermograms of MC and MHPC products showed hysteresis (Fig. 1). Unlike the base puree, the MC and MHPC formulations showed an increase in G' and complex viscosity (η^*) during heating. This may be due to increased solubilization of the hydrocolloids and extension of their chains during heating. Schwitzguebl (1990) reported a synergistic buildup of viscosity, caused by cellulose ether-starch interactions, during heating of cellulose gums in starchy food systems. The G' values started to increase at temperatures as low as 30 and 38°C, respectively, and reached maximal values of 6750 Pa at 58°C and 5510 Pa at 70°C. MC was reported to gel at 50–55°C and MHPC at a higher temperature. The gelation temperatures are affected by degree of polymerization and substitution, presence of electrolytes, and other solubles (Graham, 1978). There were sharp variations in G' values of the sweetpotato-gum products during the heating-cooling cycle. However, the changes in δ values were in a range of 11–22° (data not shown). Therefore, we were uncertain whether a clear phase transition (gel setting and melting) occurred during the thermal scans of the MC and MHPC mixtures.

The results confirmed previous observations of a shift toward lower gelling temperatures (<55°C), as indicated by increases

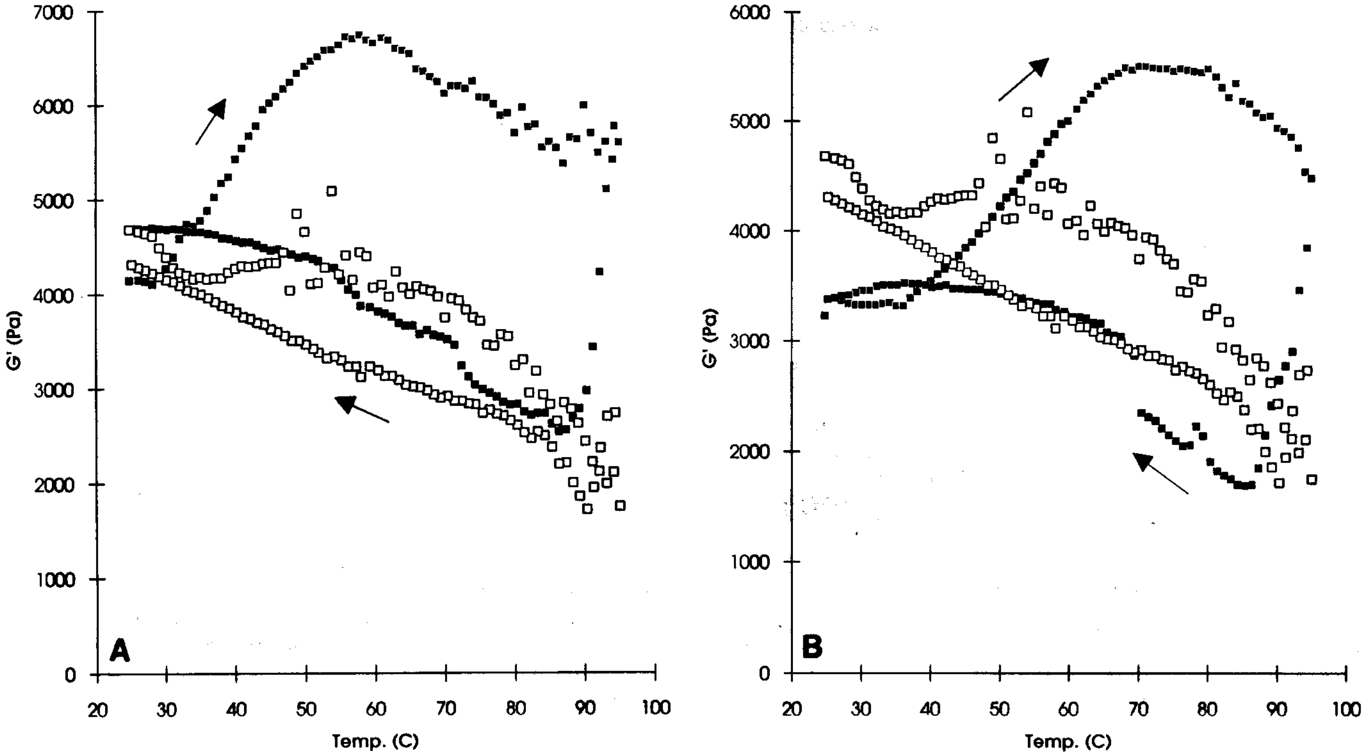

Fig. 1—Storage modulus (G') response of (A) 0.50% MC product, (B) 0.50% MHPC (■) and base puree (□) to a gradient heating (→) and cooling (←) cycle of 25–95°C. Temperature rate = 1°C/min.

of G' and G" (loss modulus), of a system containing sweetpotato starch and MC (Kohyama and Nishinari, 1992). However, the gelation patterns of the sweetpotato puree cellulose gum mixtures (i.e., lower G' on cooling than on heating (Fig. 1)) exhibited a reversed trend, as compared to that of the cellulose gum-water solutions reported by Case et al. (1992). Differences in gelation patterns of the puree-gum mixture in relation to that of the puree and/or gum, when they were treated separately, could be due to complexes formed between gums and carbohydrate components. Association between wheat starch and polysaccharide gums such as guar, xanthan, and CMC hasten the onset of the initial paste viscosity and substantially increase the final peak viscosity of wheat starch (Christianson et al., 1981). The pseudoplastic property of methylcellulose solutions is shifted to thixotropic behavior in systems containing substantial undissolved solids (Grover, 1982). Eliasson (1986) reported that the G' and G" curves were shifted toward higher values without any change in tan δ (= G"/G') when fillers such as starch granules were added to a heated starch suspension. In our puree-cellulose gum system, the added gums probably acted as fillers in the amylose/amylopectin matrix, resulting in a sharp increase in G' and n* on heating.

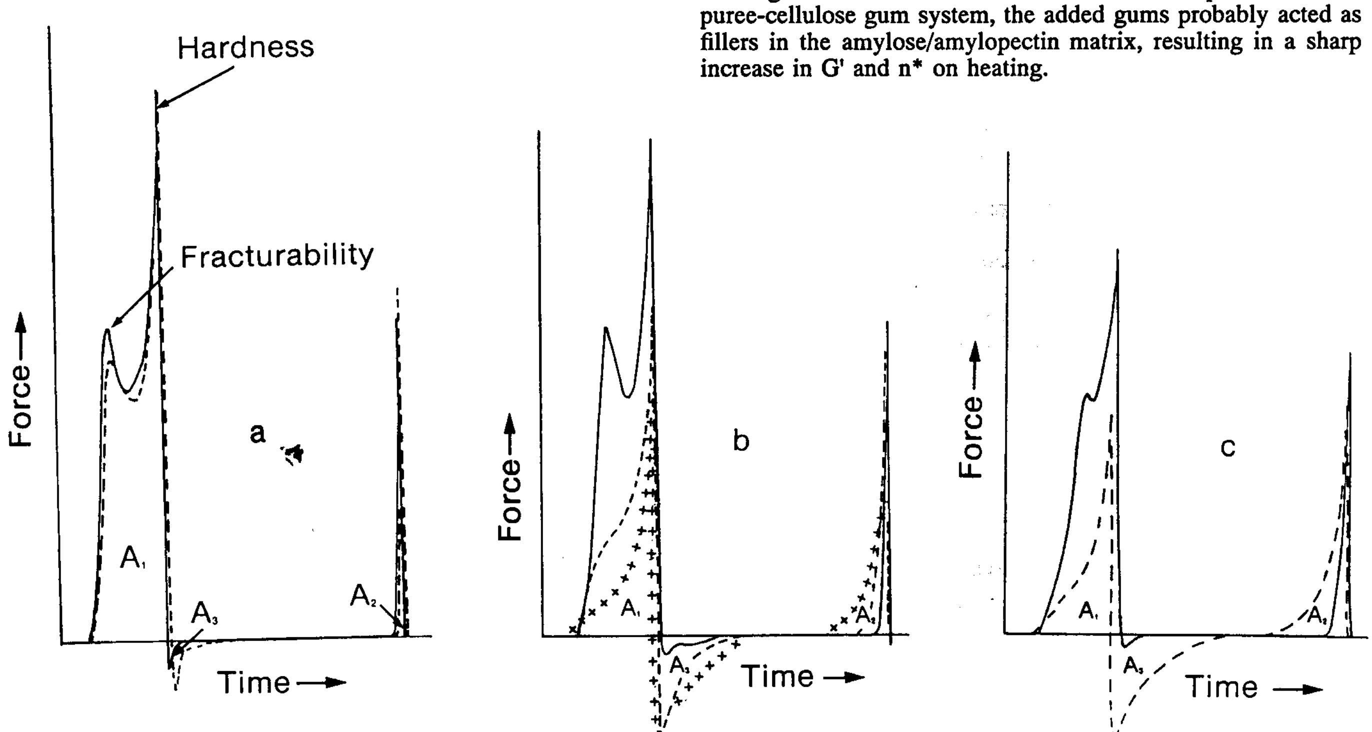

Fig. 2—Typical TPA curves of (a) baked sweetpotato roots, (b) base puree at 25°C (++++) and 0.5% MC product, and (c) base puree and 0.5% MHPC product at 25°C (– – – –) and 60°C (—). A_1, A_2 and A_3 indicate areas.

Table 2—Effect of cellulose gums on the instrumental texture profile of restructured, baked sweetpotatoes measured at 25 and 60°C

Treatment	Level (%)	Fracturability (N)	Hardness (N)	Cohesiveness	Adhesiveness (mJ)	Springiness	Gumminess (N)
Texture profiles measured at 25°C							
MC	0.25	NP	3.04*	0.70*	10.54*	0.86*	2.13*
	0.5	QP	3.95*	0.49*	9.08*	0.72*	1.97
	0.75	QP	4.88*	0.39*	8.62*	0.55*	1.90
	1.0	QP	5.66*	0.34*	8.44*	0.52*	1.86
MHPC	0.25	NP	2.69*	0.73*	8.62*	0.99*	2.04
	0.5	NP	3.70*	0.74*	13.54*	0.96*	2.77*
	0.75	NP	4.15*	0.71*	13.51*	0.93*	2.98*
	1.0	NP	4.00*	0.64*	13.25*	0.80*	2.77*
Baked roots[a]		3.75	9.82	0.08	1.20	0.11	0.75
Texture profiles measured at 60°C							
MC	0.25	1.78	5.34	0.19	3.35*	0.28*	0.91
	0.5	4.98	8.82	0.14	0.89	0.30*	1.25
	0.75	7.80*	12.80	0.13	0.76	0.28*	1.62
	1.0	10.37*	15.92	0.13	0.31	0.30*	2.12*
MHPC	0.25	2.60	4.78	0.16	1.21	0.24	0.74
	0.5	4.99	8.93	0.16	1.11	0.23	1.45
	0.75	3.80	6.85	0.16	1.16	0.24	1.09
	1.0	11.75*	12.80	0.19	0.46	0.37*	2.29*
Baked roots[a]		2.98	8.50	0.11	0.72	0.13	0.92

[a] Control.
* Significantly different from the control. NP = No peak. QP = Questionable peak.

Table 3—Textural sensory scores of sweetpotato samples evaluated by a profile panel[a]

Texture notes	Baked roots	Methylcellulose			Methylhydroxypropylcellulose		
		0.25%	0.50%	0.75%	0.25%	0.50%	0.75%
First bite							
Firmness	6.8a	5.8c	7.8b	7.8b	6.2c	8.3b	8.0b
Adhesive to palate	2.4a	3.7b	3.7b	3.2ab	2.8ab	3.2ab	2.8ab
Denseness	8.0a	8.2a	8.8a	8.0a	6.9b	7.2b	7.4b
Smoothness	6.2a	6.0a	7.2b	4.7c	6.7a	5.3c	5.0c
Moistness	6.2a	5.7a	4.2c	4.3c	5.2b	4.8c	4.8c
Mastication							
Gumminess	9.5a	11.0ab	12.0b	13.0b	9.7a	11.8b	13.3b
Adhesive to mass	4.9a	5.7b	5.7b	4.2c	7.0d	6.7d	6.8d
Fibers	3.2a	2.2b	2.7ab	2.3b	2.0b	2.0b	2.2b
Swallow							
Ease of swallow	8.8a	8.2b	7.8b	7.8b	7.7b	7.8b	7.7b
Mouth coating	3.9ab	5.0c	4.5b	3.3a	5.8c	5.5c	5.8c
Fibers	2.8a	2.0b	2.3ab	2.2b	2.0b	1.8b	1.8b
Chalkiness	1.7a	1.7a	2.8b	1.8a	2.7b	2.8b	3.2b

[a] Means in the same row with a common letter are not significantly different ($P < 0.05$).

Evaluation of product texture

Instrumental TPA. The texture profiles of the developed products were analyzed and compared with those of the baked roots (control). The typical TPA curves for baked sweetpotato roots (cv. Jewel) at 25 and 60°C showed a low adhesiveness (small A3) and low cohesiveness and springiness, as indicated by small areas and narrow widths of A2. The TPA curve at the first compression cycle had a distinct fracture peak, indicating that baked sweetpotato had a degree of stiffness. This type of TPA profile has also been reported for cooked tubers of various Irish potato cultivars (Leung et al., 1983). However, fracturability was not reported in a previous work (Wu et al., 1991) on textural properties of prebaked, frozen roots of 'Jewel' sweetpotatoes.

As shown (Fig. 2) the base puree at 25°C showed a TPA curve of a paste-type material with higher adhesiveness (larger A3), higher cohesiveness, and springiness (larger and wider width of A2). The puree tended to flow rather than break during compression, as indicated by a low initial slope and no fracturability in the first compression cycle. These characteristics were intensified at elevated temperatures, making the cutting of the puree into pieces impossible for instrumental TPA at 60°C.

At 25°C the MC and MHPC products (Fig. 2) deformed readily during compression and were not much different from that of the base puree. The mean values of TPA parameters of the baked roots and the base puree-cellulose gum products were compared (Table 2). Statistical analysis indicated that the measurement temperatures (25 and 60°C) had no effect on TPA parameters of the baked roots. However, the temperature had pronounced effects ($P < 0.05$) on hardness, cohesiveness, adhesiveness, springiness, and gumminess of all products. The added MC apparently resulted in slight increases in hardness as compared with the base puree. The hardness of the MC formulations positively correlated ($r = 0.99$) with gum concentrations. However, their cohesiveness, adhesiveness, springiness, and gumminess decreased when gum concentrations increased (Table 2). Therefore, addition of MC was beneficial to the tex-

Table 4—Mean acceptability scores of sweetpotato samples evaluated by untrained panel[a]

	Level (%)	Color	Flavor	Texture	Overvall
Baked root		6.6a	5.0c	5.9a	5.4b
MC	0.25	7.1a	6.5ab	6.3a	6.8a
	0.5	7.0a	5.3bc	5.7a	5.7b
MHPC	0.25	7.3a	6.0b	5.9a	6.6a
	0.5	7.1a	5.5bc	5.3a	6.0ab

[a] Means in the same column with a common letter are not significantly different ($P \leq 0.05$).

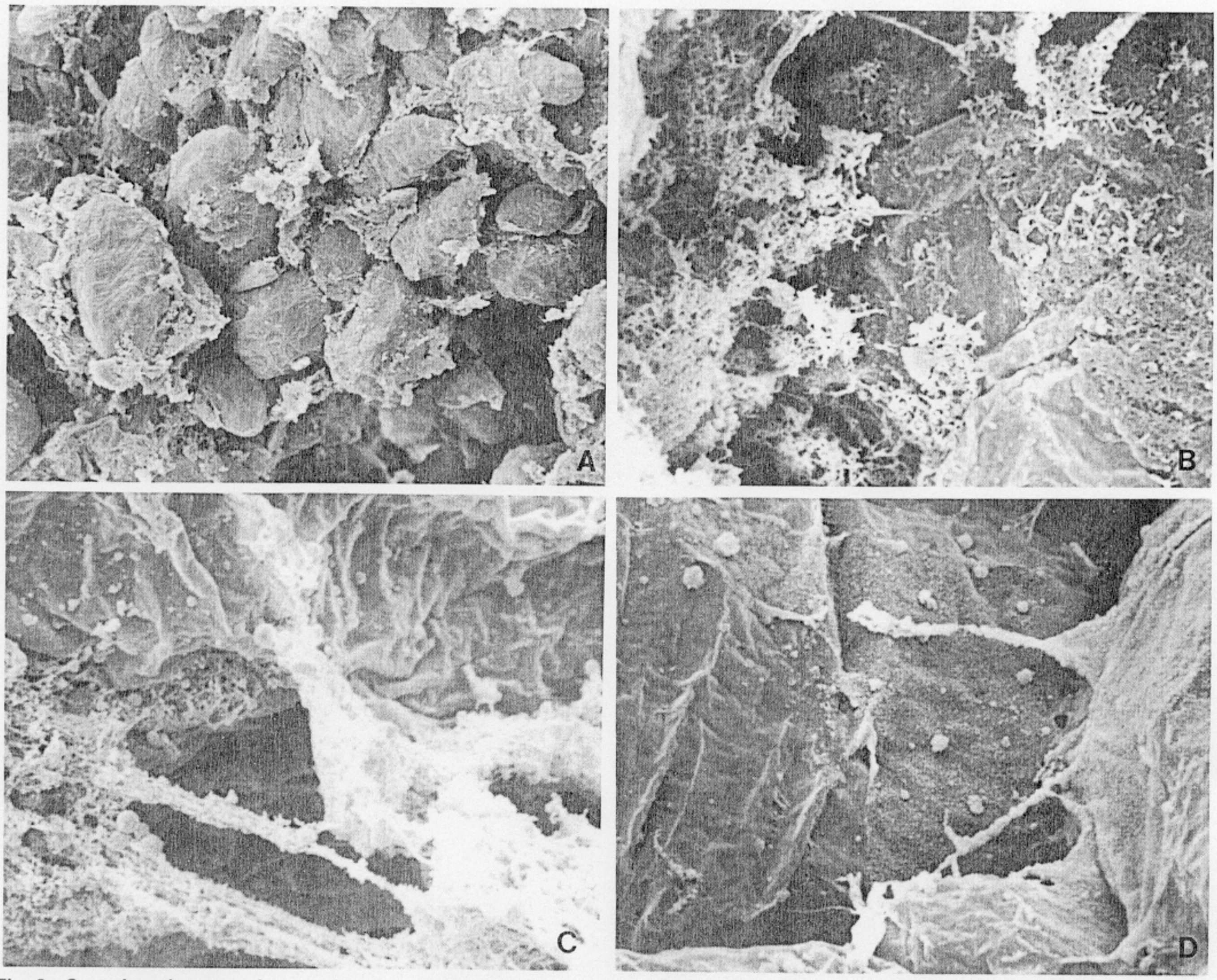

Fig. 3—Scanning electron micrographs of A = 0.5% MC product (× 244), B = 0.5% MC product (× 4248), C = 0.5% MHPC product (× 4248), and D = baked roots (× 4248).

ture of the restructured products, i.e., increased hardness, reduced adhesiveness, gumminess, etc., although the effects were slight at 25°C.

The beneficial effects of MC and MHPC on texture of the products became more pronounced when they were evaluated at high temperatures. At 60°C, the TPA curves of the 0.5% MC product and the 0.5% MHPC product (Fig. 2) showed distinct fracture peaks and had considerably smaller A3 and narrower width of A2 as compared to curves of those same products obtained at 25°C. The curves approached those of the baked roots (Fig. 2), indicating that the products may have similar textural characteristics. As shown (Table 2) none of the TPA values of the 0.25–0.75% MHPC products at 60°C were significantly different ($P < 0.05$) from the respective values for baked roots. Among MC, however, samples containing 0.25% gum had a higher adhesiveness and springiness but similar values of other TPA parameters as the control. Increasing the MC concentration to 0.50% reduced adhesiveness of the product to the level of baked roots but did not affect springiness which was significantly higher ($P < 0.05$) than baked root. Correlations between gum concentrations and TPA parameters at 25°C did not all apply in the hot samples. For MC products a positive correlation ($r = 0.99$) occurred between gum concentrations and gumminess of samples at 60°C, while at 25°C the parameter was negatively correlated ($r = -0.95$). For the MHPC samples at 60°C, increases in gum concentrations resulted in an increase of all TPA values, except adhesiveness (Table 2). The adhesiveness at 60°C of all MHPC products was low and not significantly different from baked sweetpotatoes. The results confirm the importance of sample temperature when evaluating effects of thermally-sensitive gelling agents on food texture (Szczesniak, 1975).

Sensory texture profile

For the 0.25–0.75% gum products, the profile panel detected a significant difference between gums for first-bite denseness (FBD) with the MC products more intense. First-bite adhesiveness, mastication fibers (MF), ease of swallow (ES) and residual fibers were not affected by gums or their concentrations (Table 3).

Baked sweetpotatoes from stored roots were also evaluated by the profile panelists for comparison. For all described texture notes, none of the gum products were consistently given the same scores as baked roots. However, those products containing 0.25–0.50% MC or MHPC were rated nearly equal for several texture notes, including all first-bite descriptors (except firmness), mastication-chewiness (MCHEW), MF, ES, and chalkiness (Table 3). Panelists commented that sensory characteristics of baked roots were between those of the 0.25–0.50% gum formulations, and closest to the 0.25% level in overall texture. All samples were easily mashed in the mouth and mixed well with saliva. The shear force needed to break down samples during mastication was more intense in formulations with 0.50% or more of gums than in the baked roots or products containing 0.25% of gums.

Sensory scores significantly correlated ($P < 0.05$) with the 60°C instrumental TPA values for gumminess ($r = 0.72$) and parameters involving product firmness such as fracturability ($r = 0.74$) and hardness ($r = 0.65$). Similarly, sensory scores for TPA hardness of Irish potatoes were more highly correlated with fracturability than with hardness obtained by TPA (Leung et al., 1983). However, sensory scores for adhesiveness and mouth coating did not correlate with TPA adhesiveness.

Product acceptability by untrained panel

Based on evaluation by the profile panel, the 0.25–0.50% gum products and the baked roots were evaluated by an untrained panel for acceptability. No significant difference for color and texture acceptability was noted among the samples (Table 4). However, significant differences ($P < 0.05$) occurred in flavor and overall acceptability. The 0.25% MC or MHPC products were preferred over baked roots while the 0.50% gum products were rated similar to baked roots. Several panelists detected a "sour" and "old" flavor in the baked roots.

L, a, b values

The baked roots had L, a, and b values of 57.2, 21.3, and 41.6, respectively, similar to values reported by Wu et al. (1991) for prebaked-frozen sweetpotatoes of Jewel cultivar. The 0.25–0.50% products had the same values for L (56.6–56.8), a (19.4–19.9), and b (36.7–37.4). The difference in lightness (L value) between the selected products and the baked roots was not significant. However, the a and b values of the products were significantly lower than those of the roots, indicating that restructured products had less redness and yellowness. The beta carotene content of baked Jewel cultivar has been reported as high as 6.26-7.99 mg/100 g (Wu et al., 1991).

Microstructure

Examination of SEM photomicrographs revealed that many gelatinized starch granules in the puree, although wrinkled and crumpled, were intact and, therefore, unable to bond together. The added MC was scattered through the matrix and was attached to the surface of the gelatinized starch granules (Fig. 3). Higher magnification revealed that the added MC formed a mesh-like network (Fig. 3) which held the granules together and probably provided rigidity. Similar structure was observed in the MHPC formulation (Fig. 3). In sweetpotato patties the added ingredients (starch, sugar, etc.) formed an amorphous, glue-like material that provided the rigidity to retain the patty shape (Walter and Hoover, 1984). In the baked roots, the cell walls were completely destroyed, but many gelatinized starch granules still retained integrity and shape (Fig. 3). This observation was not in agreement with Damir (1989), who reported a complete shape deformation of starch granules of an Egyptian sweetpotato cultivar baked at 175°C for 60 min. The degree of deformation of starch granules and other carbohydrate components associated with the structure of baked sweetpotato apparently varies among sweetpotato cultivars, and may contribute to differences in texture.

CONCLUSIONS

THE FOOD GUMS, MC AND MHPC, at 0.25% were excellent restructuring agents for sweetpotato puree. The restructured system required minimal preparation and retained the textural and flavor characteristics of traditionally baked sweetpotatoes. In order to accurately assess physical and sensory characteristics of systems containing ingredients such as MC and MHPC, which form thermally reversible gels, evaluation must be carried out at temperatures where the gel network is retained.

REFERENCES

Anonymous. 1993. Dow food additive lowers cholesterol levels. Chem. and Eng. News, June 28: 36.
Aqualon. 1992. Benecel: Physical and Chemical Properties. Aqualon Co., Wilmington, DE.
Bell, D.A. 1990. Methylcellulose as a structure enhancer in breadmaking. Cer. Foods World 35: 1001.
Bourne, M.C. 1978. Texture profile analysis. Food Technol. 32: 62.
Bouwkamp, J.C. 1985. Processing of sweetpotatoes: Canning, freezing, and dehydrating. In *Sweetpotatoes: a Natural Resource for the Tropics,* J.C. Bouwkamp (Ed.), p. 185–203. CRC Press, Boca Raton, FL.
Brandt, M.A., Skinner, E.Z., and Coleman, J.A. 1963. Texture profile method. J. Food Sci. 28: 404.
Case, S.E., Knopp, J.A., Hamann, D.D., and Schwartz, S.J. 1992. Characterization of gelation of konjac mannan using lyotropic salts and rheological measurements. In *Gums and Stabilizers for the Food Industry,* P.A. Williams and D.J. Wedlock (Ed.), Vol. 6, p. 489–500. Oxford University Press, New York.
Caul, J.F. 1957. The profile method of flavor analysis. Adv. Food Res. 7: 1.
Christianson, D.D., Hodge, J.E., Osborne, D., and Detroy, R.W. 1981. Gelatinization of wheat starch as modified by xanthan gum, guar gum, and cellulose gum. Cer. Chem. 58: 513.
Civille, G.V. and Szczesniak, A.S. 1973. Guidelines to training a texture profile panel. J. Texture Studies 4: 204.
Collins, J.L. and Walter, W.M., Jr. 1992. Processing and processed products. In *Fifty Years of Cooperative Sweetpotato Research 1939–1989.* A. Jones and J.C. Bouwkamp (Ed.), p. 71–87. Southern Cooperative Series Bull. No. 369, Baton Rouge, LA.
Damir, A.A. 1989. Effect of heat penetration during cooking on some physicochemical properties and microstructure of sweetpotatoes. Food Chem. 34: 41.
Dziezak, J.D. 1991. A focus on gums. Food Technol. 45: 116.
Eliasson, A.C. 1986. Viscoelastic behaviour during the gelatinization of starch. I. Comparison of wheat, maize, potato, and waxy-barley starches. J. Text. Stud. 17: 253.
Glicksman, M. 1984. The Role of Hydrocolloids in Food Processing: Cause and Effect. In *Gums and Stabilizers for the Food Industry,* G.O. Philiplips, D.J. Wedlock, and P.A. Williams (Ed.), Vol. 2, p. 297–320. Pergamon Press, Oxford, England.
Graham, H.D. 1978. Colloidal dispersions: Polysaccharide gums. In *Encyclopedia of Food Science,* M.S. Peterson and A.H. Johnson (Ed.), p. 170. Avi, Westport, CT.
Grover, J.A. 1982. Methylcellulose and hydroxypropylmethylcellulose. In *Food Hydrocolloids,* M. Glicksman (Ed.), Vol. 3, p. 122–153. CRC Press, Inc., Boca Raton, FL.
Hannigan, K. 1983. Many possibilities for structured fruit. Food Eng. 55: 48.
Kohyama, K. and Nishinari, K. 1992. Cellulose derivatives effects on gelatinization and retrogradation of sweetpotato starch. J. Food Sci. 57: 128.
Leung, H.K., Barron, F.H., and Davis, D.C. 1983. Textural and rheological properties of cooked potatoes. J. Food Sci. 48: 1470.
Mandigo, R.W. 1986. Structuring of muscle foods. Food Technol. 40: 85.
Montejano, J.G., Hamann, D.D., and Lanier, T.C. 1985. Comparison of two instrumental methods with sensory texture of protein gels. J. Text. Stud. 16: 403.
Pak, P.K. 1982. Development of frozen sweetpotato patty suitable for restaurant handling. M.S. thesis, Mississippi State Univ., Mississippi State, MS.
SAS Institute, Inc. 1988. *SAS/STAT User's Guide.* SAS Institute, Inc., Cary, NC.
Schwitzguebl, T. 1990. The application of cellulose ether-starch interactions in food formulations. In *Gums and Stabilizers for the Food Industry,* G.O. Philiplips, D.J. Wedlock, and P.A. Williams (Ed.), Vol. 5, p. 425–435. Pergamon Press, Oxford, England.
Szczesniak, A.S. 1975. Textural characterization of temperature sensitive foods. J. Text. Stud. 6: 139.
Walter, W.M. Jr. 1987. Effect of curing on sensory properties and carbohydrate composition of baked sweetpotatoes. J. Food Sci. 52: 1030.
Walter, W.M. Jr. and Hoover, M. W. 1984. Effect of pre-processing storage conditions on the composition, microstructure, and acceptance of sweetpotato patties. J. Food Sci. 49: 1258.
Walter, W.M., Jr. and Schadel, W.E. 1982. Effect of lye peeling conditions on sweetpotato tissue. J. Food Sci. 47: 813.
Walter, W.M. Jr. and Schwartz, S.J. 1993. Controlled heat processing of 'Jewel' sweetpotatoes for puree production. J. Food Qual. 16: 71.
Woolfe, J.A. 1992. *Sweetpotato: An Untapped Food Resource.* Cambridge University Press, Cambridge, England.
Wu, J.Q., Schwartz, S.J., and Carroll, D.E. 1991. Chemical, physical and sensory stabilities of prebaked frozen sweetpotatoes. J. Food Sci. 56: 710.

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