Reprinted from *J. Food Sci.*
60(5): 1054–1059 & 1074
©1995 Institute of Food Technologists

Texturization of Sweetpotato Puree with Alginate: Effects of Tetrasodium Pyrophosphate and Calcium Sulfate

V.D. TRUONG, W.M. WALTER, JR., and F.G. GIESBRECHT

ABSTRACT

The effects and optimum levels of tetrasodium pyrophosphate (TSPP), alginate and calcium sulfate (CaSO$_4$) on physical and sensory characteristics of texturized sweetpotato puree were studied using response surface methodology. Samples were subjected to instrumental texture profile analysis (TPA) and sensory evaluation. Prediction models to describe the effects of ingredients on TPA parameters were used to generate contour plots for optimization using TPA values of baked roots as the limits. The optimum formulations having textural characteristics of the baked roots were within the following identified regions: (a) at 0.12% TSPP, alginate, 0.20–0.25%, and CaSO$_4$, 0.40–0.70%; (b) at 0.18% TSPP, alginate, 0.20–0.55%, and CaSO$_4$, 0.22–0.42%. A taste panel scored representative formulations of the optimum regions similar to the baked roots for color, flavor, texture, and overall acceptability.

Key Words: restructured products, texture profile, response surface

INTRODUCTION

MANY REPORTS on various aspects in production of sweetpotato puree have been published (Collins and Walter, 1992). However, there are few accounts of restructured sweetpotato products (Walter and Hoover, 1984; Hoover et al., 1983; Pak, 1982). We have recently published a report on sweetpotato puree restructured with cellulose derivatives (Truong and Walter, 1994). This cellulose gum-texturized product requires minimum home preparation time and has sensory characteristics of traditionally baked sweetpotatoes. However, due to thermally induced gelling properties of cellulose gums, the product retains its texture only at elevated temperature (>50°C). Therefore, it has to be consumed hot, and this may be a limitation of the developed technology.

Alginate is different from cellulose gums in that it forms chemically, rather than thermally, induced gels. The gel network is formed by inter-molecular association of polyvalent cations such as calcium with the polyguluronate sites of alginate molecule (Sime, 1984). Under suitable conditions, alginate gelation can take place at room temperature, resulting in mechanically and thermally stable gels. The alginate/calcium binding technology has proven useful for production of restructured products from fruits and muscle foods (Luh et al., 1976; Hannigan, 1983; Mandigo, 1986; Schmidt and Means, 1986; Pelaez and Karel, 1981). However, there is limited information on its applicability in food systems with high starch content such as sweetpotato puree.

Several factors including pH, temperature, type, and concentration of alginates; calcium salts; and sequestrants used to bind the amount of available calcium affect the gelling reaction (Imeson, 1990). Interactions between sodium alginate, calcium carbonate, and organic acids affecting textural properties of the products have been studied in restructured meat systems (Johnson et al., 1990; Means et al., 1987; Shand et al., 1993; Trout et al., 1990) and fabricated fruits (Kaletunc et al., 1990; Nussinovitch and Peleg, 1990). Effects of endogenous available calcium on alginate gelation were not studied. Furthermore, investigation on optimization of these parameters using response surface methodology (RSM) has been limited. Using RSM, Mouquet et al. (1992) obtained the optimum ingredient concentrations and processing treatments for mechanical and thermal stability of alginate texturized mango pulp. However, sensory characteristics of the product were not determined.

Our objectives were to (1) explore the feasibility of alginate texturization of sweetpotato puree into restructured products, (2) determine the effects and optimum levels of calcium sequestrant, alginate and calcium salt on textural properties using RSM and (3) evaluate sensory characteristics of combinations which fell in the optimum regions of contour plots, as compared with traditionally baked sweetpotatoes.

MATERIALS & METHODS

Experimental design

Based on preliminary experiments, independent variables affecting texture of restructured sweetpotatoes were tetrasodium pyrophosphate (TSPP) (X1), alginate (X2) and calcium sulfate (X3). A rotatable design with three independent variables (Cochran and Cox, 1957; Mullen and Ennis, 1979) was adopted. Each independent variable had five levels with a central value, and intervals between levels were selected according to preliminary studies: X1 = 0, 0.06, 0.12, 0.18, and 0.24% of the formulation; X2 = 0.20, 0.40, 0.60, 0.80, and 1.00%; and X3 = 0.15, 0.30, 0.45, 0.60, and 0.75%. The experimental design required 15 treatment combinations, with the center point replicated five times (T-15 to T-19). Coded variables and actual percentages of ingredients used in the formulations are shown in Table 1. The experiment was performed with two replications. Dependent variables were the parameters of the instrumental texture profile analysis (TPA) which included fracturability, hardness, cohesiveness, adhesiveness, springiness, and gumminess.

Preparation of puree

Jewel cultivar sweetpotatoes were utilized. The roots were cured and stored at 13–16°C and 80–90% relative humidity (RH) for 5 mo prior

Table 1—Coded and uncoded variables in the treatment formulations of sweetpotato puree texturized with alginate/calcium

Treatment combination	Code			%		
	X1	X2	X3	TSSP	ALG	CaSO$_4$
1	−1	−1	−1	0.06	0.4	0.3
2	−1	−1	1	0.06	0.4	0.6
3	−1	1	−1	0.06	0.8	0.3
4	−1	1	1	0.06	0.8	0.6
5	1	−1	−1	0.18	0.4	0.3
6	1	−1	1	0.18	0.4	0.6
7	1	1	−1	0.18	0.8	0.3
8	1	1	1	0.18	0.8	0.6
9	1.682	0	0	0.24	0.6	0.45
10	−1.682	0	0	0	0.6	0.45
11	0	1.682	0	0.12	1	0.45
12	0	−1.682	0	0.12	0.2	0.45
13	0	0	1.682	0.12	0.6	0.75
14	0	0	−1.682	0.12	0.6	0.15
15	0	0	0	0.12	0.6	0.45
16	0	0	0	0.12	0.6	0.45
17	0	0	0	0.12	0.6	0.45
18	0	0	0	0.12	0.6	0.45
19	0	0	0	0.12	0.6	0.45

Author Truong is with the Dept. of Food Science, N.C. State Univ., Raleigh, NC 27695-7624; author Giesbrecht is with the Department of Statistics, North Carolina State University, Raleigh, NC 27695-8205. 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.

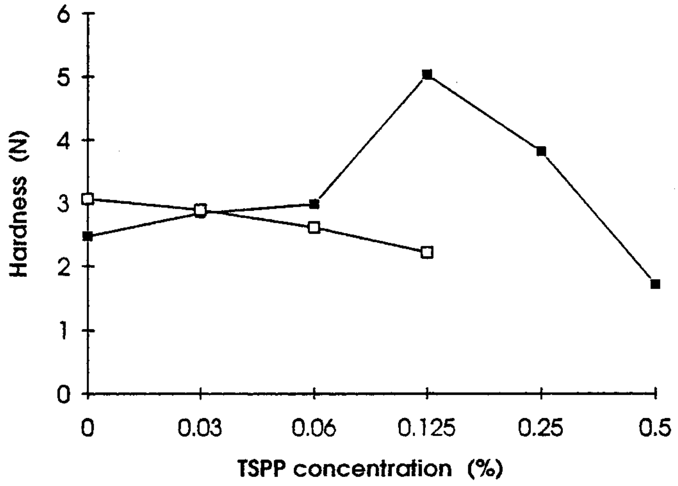

Fig. 1—Effect of TSPP and $CaSO_4$ concentration on gel hardness of restructured sweetpotato texturized with 0.5% alginate. (□) 0.15% $CaSO_4$, (■) 0.45% $CaSO_4$.

Table 2—Mean values of instrumental texture profile parameters of treatment formulations and baked sweetpotato roots (control) measured at 25°C

Treatment combination	Fracturability (N)	Hardness (N)	Cohesiveness (%)	Adhesiveness (mJ)	Springiness (%)	Gumminess (N)
1	1.13	3.00	49.43	10.91	96.39	1.49
2	1.53	3.85	32.53	6.55	44.31	1.23
3	2.19	4.62	32.23	9.59	53.20	1.49
4	2.60	5.53	24.09	7.16	32.49	1.32
5	4.27	6.47	14.52	4.10	27.42	0.94
6	9.26	10.80	10.20	1.27	26.93	1.10
7	8.44	9.71	15.97	5.02	40.98	1.55
8	19.73	19.86	11.31	0.23	30.94	2.25
9	10.58	10.75	11.01	1.51	30.82	1.17
10	0.37	3.04	67.99	12.82	117.76	2.06
11	21.18	19.72	9.16	0.18	31.12	1.79
12	3.86	6.41	13.21	2.85	23.68	0.82
13	9.21	12.51	11.24	0.84	29.49	1.35
14	2.09	3.92	44.86	15.77	119.67	1.76
15	13.54	13.64	10.51	0.93	26.61	1.43
16	8.34	12.49	11.82	1.14	28.45	1.45
17	11.47	13.76	11.55	0.92	29.45	1.54
18	13.93	13.16	10.19	0.77	31.50	1.34
19	10.90	14.27	10.82	0.99	29.32	1.53
Baked roots	4.10	8.70	7.80	1.23	13.52	0.68

Table 3—Analysis of variance of overall main effects of ingredient concentration, coefficients of determination (R^2) and significance of the full regression models for TPA values

	F-ratio					
Independent variable	Fracturability	Hardness	Cohesiveness	Adhesiveness	Springiness	Gumminess
TSPP	18.97**	22.10**	149.22**	50.86**	27.27**	2.80
ALG	16.76**	19.24**	3.61	0.90	0.18	18.13**
$CaSO_4$	6.23*	12.05**	38.15**	46.68**	25.25**	0.19
R^2	0.87	0.90	0.97	0.94	0.91	0.80
F-ratio for total regression	6.71**	8.73**	32.29**	16.37**	9.95**	3.96*

* Significant at P < = 0.05; ** Significant at P < = 0.01.

to use. The puree was prepared as previously described (Truong and Walter, 1994) and had the following composition (fwb): dry matter, 21.92%; alcohol-insoluble solids, 9.40%; starch, 4.14%; fructose, 1.56%; glucose, 1.62%; sucrose, 7.17%; and maltose, 6.45%.

Preparation of restructured sweetpotatoes

Texturization of sweetpotato puree was carried out by mixing the sweetpotato puree with other ingredients in an electronic chopper (Model UMC5, Stephan Co., West Germany) at 1800 rpm for 3 min with interval interruptions. Each formulation (1 kg) contained, in addition to sweetpotato puree, 60g sucrose and amounts of TSPP (Rhone-Poulenc, Shelton, CT), alginate (type Manugel-DMB, Kelco, Rahway, NJ) and calcium sulphate dihydrate (Merck and Co., Inc., Rahway, NJ) equivalent to levels indicated (Table 1). The 6% sucrose added to the formulation was intended to raise the sugar level of puree to attain sweetness usually preferred for baked sweetpotato (Truong and Walter, 1994). Ingredients were mixed with the puree according to the following sequence: first, TSPP pre-mixed in 20g sucrose, followed by alginate-sucrose mix, and calcium sulfate suspended in 20 mL of water. Mixing time was 60 sec after adding each ingredient mix. The blended mixture was immediately extruded into 5.5 cm diameter sausage casings and clipped to form rolls of about 10 cm in length, and the ends fastened. The rolls were aged for 24 hr at 4°C, frozen, and stored at −20°C.

Sensory evaluation

Before baking, sausage casings of frozen restructured 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 (Truong and Walter, 1994). The elapsed time between sample preparation and evaluation was about 1–2 hr. The product texture was stable under these conditions. The temperature of 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. Middle portions of baked roots were cut into slices similar to those of restructured sweetpotatoes.

Samples of selected formulations and baked roots were subjected to an acceptability test by a 30-member, untrained panel consisting of faculty, staff, and graduate students, from the Department of Food Science at North Carolina State Univ. At each testing, panelists were asked to evaluate four samples in a random order for color, flavor, texture and overall acceptability on a 9-point hedonic scale (9 = like extremely, 1 = dislike extremely). All panel sessions were conducted in sensory panel booths under fluorescent light.

Physical measurements

Instrumental texture profile parameters were determined at 25°C following the TPA procedure. Fracturability, hardness, adhesiveness, 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 (Montejano et al., 1985). Cohesiveness and springiness were expressed in percentage. Baked samples were cooled at room temperature for several hours and cut into 2 cm cubes (about 8–9g). Cubes of restructured and baked root samples were weighed and then subjected to 75% double compression and relaxation using an Instron Universal Testing Machine (Model 1122, Instron Inc., Canton, MA) fitted with a 50 kg-load cell which was attached with a plunger having a 5.7 cm diameter compression anvil. The measurements were performed with a crosshead speed of 10 cm/min and a chart speed of 20 cm/min. At least four measurements were taken for each sample of the formulated sweetpotatoes. Baked roots of similar size and shape were used, and samples were taken at the middle part of each root. Data were expressed in unit of texture profile parameters per 10-g sample.

Hunter color values (L, a, b) were determined from reflectance measurements using a Spectrogard color system (Pacific Scientific, Silver Spring, MD) with daylight illuminant.

Calcium determination

Calcium content was determined following the spectrophotometric procedure (Gindler and King, 1972).

Statistical analysis

All analyses were performed using the Statistical Analysis System (SAS Institute, Inc. 1989). A second order response surface model which had linear, quadratic, and all interaction terms for the three independent variables was fitted to the TPA data of the 19 treatment combinations. Dependent variables were the TPA parameters including fracturability, hardness, cohesiveness, adhesiveness, springiness, gumminess and chewiness. Independent variables which were found significant at P < 0.05 in the full model were retained in the reduced models. The best final model was obtained following the step-wise regression procedure described by Draper and Smith (1981). Models that were significant (P < 0.05) with R^2 > 0.70 were used to generate contour plots for each TPA

Table 4—Best selected prediction models for instrumental texture profile parameters[a]

Dependent variable	Prediction equation	R^2
Fracturability	$y = -33.75 + 174.17X_1 + 16.06X_2 + 81.64X_3 - 488.40X_1^2 - 76.20X_3^2$	0.79
Hardness	$y = -27.22 + 164.62X_1 + 13.19X_2 + 71.21X_3 - 489.47X_1^2 - 63.65X_3^2$	0.82
Cohesiveness	$y = 150.31 - 864.80X_1 - 44.99X_2 - 215.61X_3 + 293.75X_1X_2 + 1999.78X_1^2 + 192.69X_3^2$	0.96
Adhesiveness	$y = 38.73 - 153.76X_1 - 93.22X_3 + 440.08X_1^2 + 83.08X_3^2$	0.93
Springiness	$y = 253.29 - 1017.37X_1 - 551.94X_3 + 3049.82X_1^2 + 491.19X_3^2$	0.83
Gumminess	$y = 3.22 - 20.05X_1 - 0.90X_2 - 2.31X_3 + 17.39X_1X_2 + 17.92X_1X_3$	0.72

[a] X_1 = TSPP; X_2 = alginate; X_3 = $CaSO_4$.

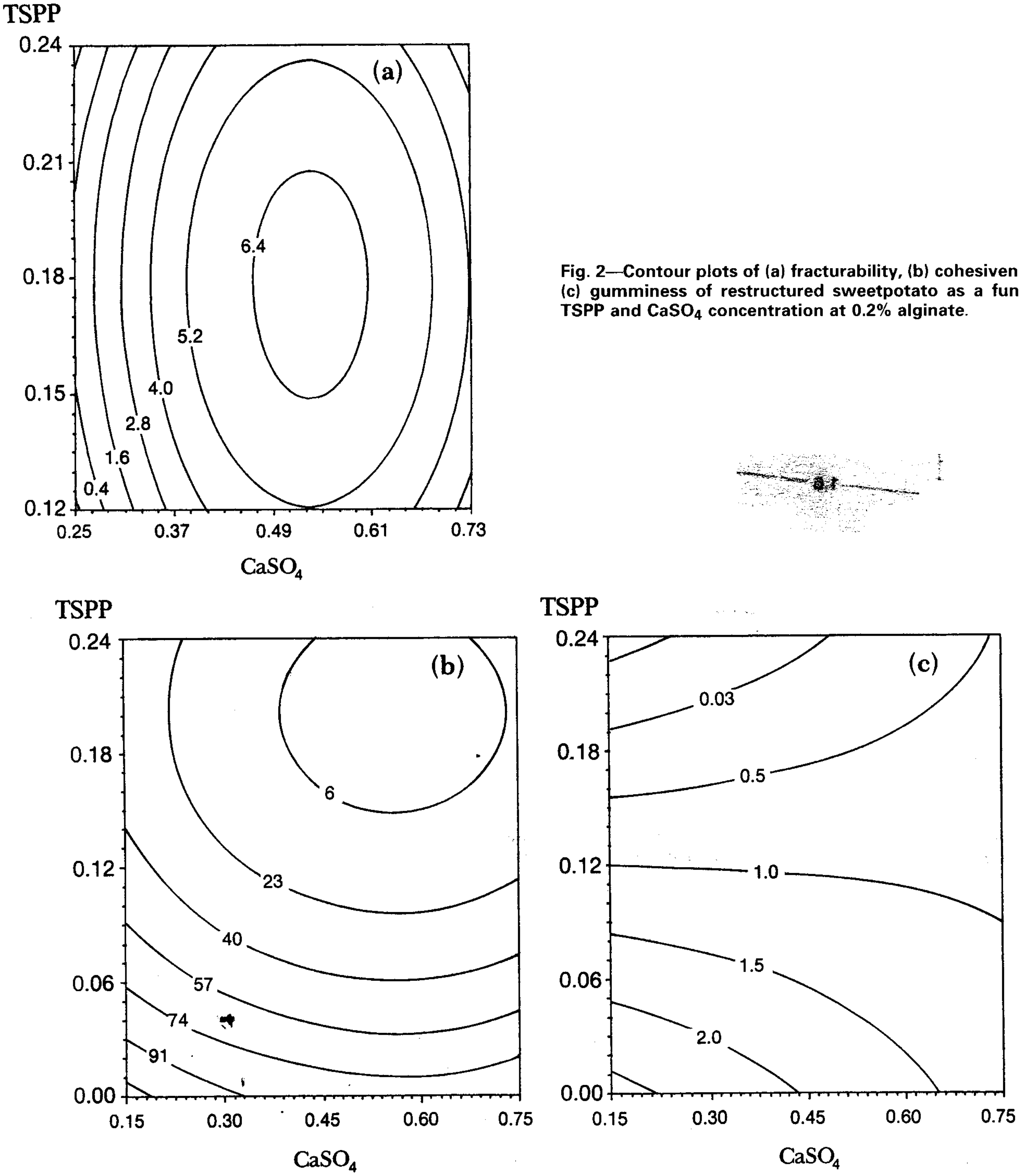

Fig. 2—Contour plots of (a) fracturability, (b) cohesiveness, and (c) gumminess of restructured sweetpotato as a function of TSPP and $CaSO_4$ concentration at 0.2% alginate.

parameter as a function of two variables, while the other variable was held constant.

The baked roots served as the control, and ranges of their TPA values were used to set limits in each contour plot for identification of an acceptable region. Contour plots for TPA parameters were superimposed, and regions of overlap were shaded. The overlapping area indicates the treatment combinations which are expected to have textural characteristics similar to baked roots.

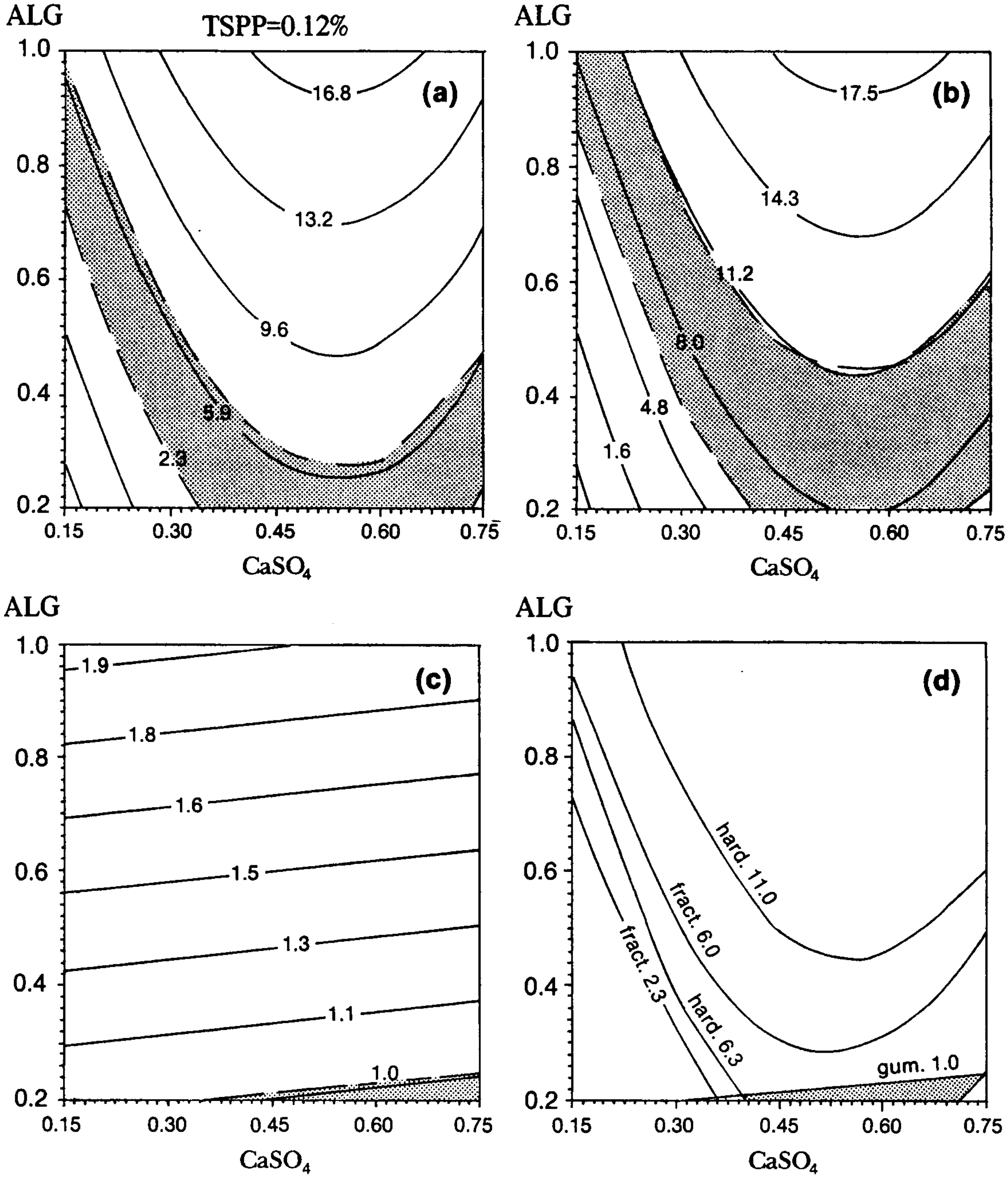

Fig. 3—Contour plots of (a) fracturability, (b) hardness, (c) gumminess of restructured sweetpotato as a function of alginate and $CaSO_4$ concentration at 0.12% TSPP with shaded regions covering the limits of the control, and (d) optimum (shaded) region obtained by superimposing (a), (b) and (c).

RESULTS & DISCUSSION

Texturizing conditions

The calcium content of sweetpotato puree was 33.71 mg/100g which was in the range of 17–45 mg reported for sweetpotato roots (Kays, 1992). Picha (1985) also obtained a similar result of 30 mg calcium/100g in 'Jewel' sweetpotato roots. Available calcium can readily interact with added alginate, resulting in premature gel formation and, consequently, gel softness (Imeson, 1990). Therefore, TSPP was used as a calcium sequestrant and was dispersed in puree prior to addition of alginate and calcium sulfate. However, at a given alginate concentration (e.g. 0.50%, w/w) increasing TSPP concentration in the formulation could result in an increase or decrease in gel hardness (Fig. 1), depending on the amount of calcium sulfate available to interact with alginate. Optimal concentrations of these ingredients should be determined to obtain gel characteristics suitable for a given texturized product.

In preparation of the designed formulations (Table 1), we observed that the setting time before gelation varied from <10 min to 1–2 hr. In addition, the source of calcium sulfate had an effect on gelation time. The gel hardness reached maximum after aging at 4°C for 24 hr. According to Nussinovitch and Peleg (1990) the physical and chemical equilibrium of alginate gels can take from 6 to >48 hr. However, measurements of mechanical properties of the gels can be performed after 24 hr since changes after that are relatively small.

Freezing and thawing of the sweetpotato puree-alginate gel resulted in lowering of its hardness and fracturability values by 30% and 50%, respectively. However, cohesiveness, adhesiveness, and springiness were unchanged. The alginate gel is thermally stable (Imeson, 1990). Baking the sweetpotato-

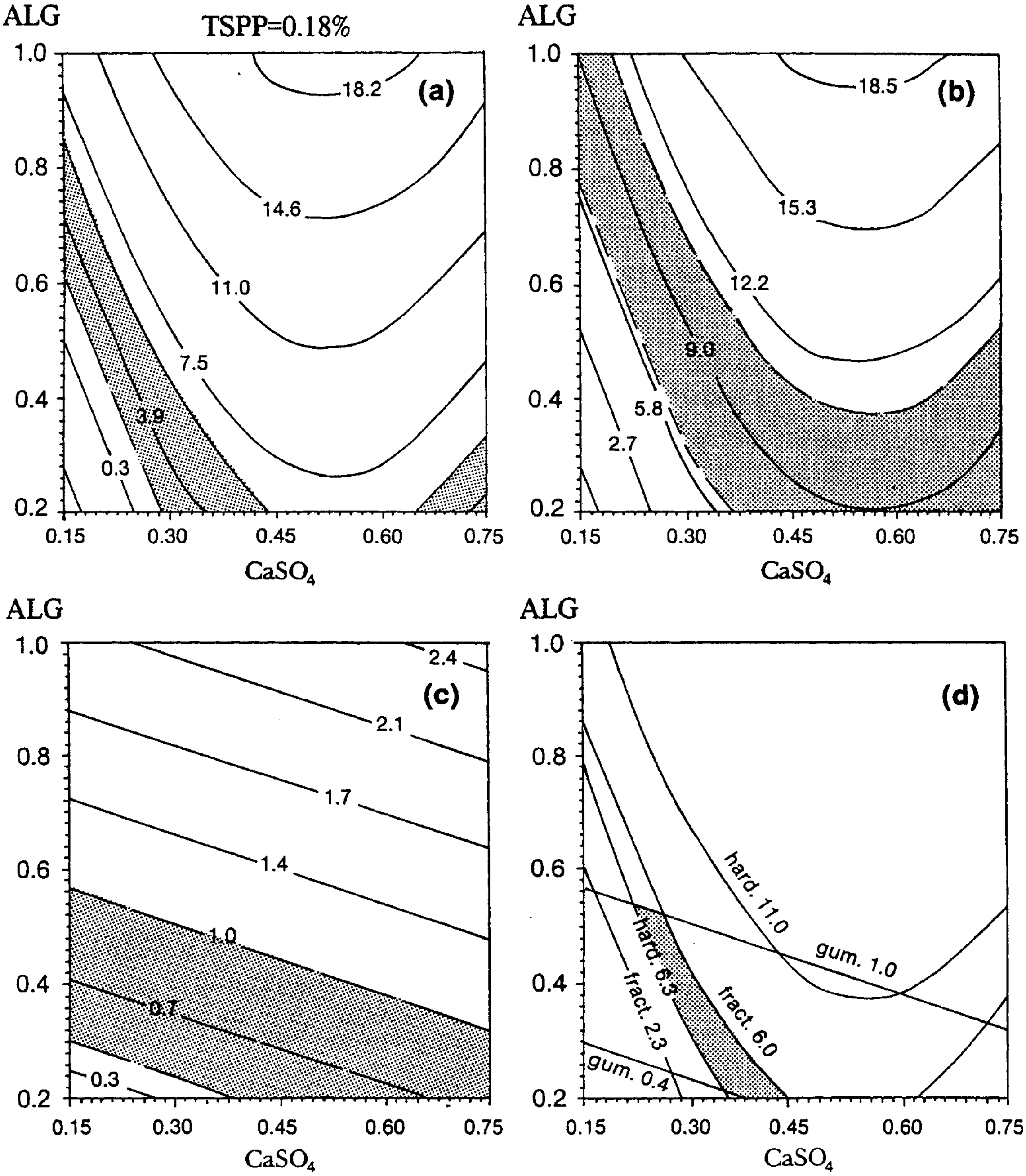

Fig. 4—Contour plots of (a) fracturability, (b) hardness, (c) gumminess of restructured sweetpotato as a function of alginate and $CaSO_4$ concentration at 0.18% TSPP with shaded regions covering the limits of the control, and (d) optimum (shaded) region obtained by super-imposing (a), (b) and (c).

alginate gel at 204°C for 15 min had no effect on any TPA parameters.

Model fitting and mapping of contour plots

The mean values of TPA parameters for the 19 treatment combinations and baked sweetpotato roots are summarized (Table 2). Multiple regression analysis resulted in significant full models ($P < 0.05$) for all dependent variables. The TSPP and $CaSO_4$ concentrations had significant main effect ($P < 0.05$) on all TPA parameters except gumminess (Table 3). On the other hand, the main effect of alginate levels was significant only for fracturability, hardness, and gumminess. Most interaction terms of the independent variables in the full model showed no significant effect on TPA parameters (data not shown).

Stepwise regression analysis resulted in reduced models (Table 4). These were not significantly different ($P < 0.05$) from the full model, based on the F-test, and were used to generate contour plots for TPA parameters. A contour plot of fracturability of restructured sweetpotatoes containing 0.20% alginate as a function of TSPP and $CaSO_4$ concentrations is shown (Fig. 2a). A similar contour plot pattern was obtained for hardness (graph not shown). Increasing TSPP and $CaSO_4$ concentrations resulted in an increase in these firmness parameters with maximal values at 0.18% TSPP and 0.56% $CaSO_4$.

A contour plot for cohesiveness as a function of TSPP and $CaSO_4$ at 0.20% alginate was compared (Fig. 2b). Unlike fracturability and hardness, cohesiveness decreased as concentration of TSPP and $CaSO_4$ increased. Contour plots for adhesiveness and springiness exhibited the same pattern (graphs not shown). Optimal TSPP and $CaSO_4$ levels for these TPA parameters were also attained at about 0.14–0.17% and 0.56%, respectively. A formulation containing these optimal levels (0.16% TSPP, 0.56% $CaSO_4$) and 0.20% alginate which was F-0.2Alg was prepared for including in acceptability tests for comparison.

Gumminess, the product of hardness and cohesiveness (Bourne, 1978) was linearly related to TSPP, alginate and $CaSO_4$ concentrations (Table 4). Contour plots of gumminess at 0.20% alginate (Fig. 2c) exhibited different patterns from other TPA parameters. Increasing both TSPP and $CaSO_4$ concentrations resulted in a corresponding decrease in gumminess of the formulations having less than 0.12% TSPP. However, with TSPP levels >0.12%, reduction in gumminess could be obtained by lowering the amount of $CaSO_4$.

In order to observe the effects of alginate and $CaSO_4$ on product texture, contour maps of TPA parameters were plotted at constant TSPP levels. At TSPP concentrations of 0.12% (Fig. 3a and 3b) and 0.18% (Fig. 4a and 4b), fracturability and hardness increased with increasing levels of both alginate and $CaSO_4$. Gumminess values decreased with reduced alginate levels (Fig. 3c and 4c). Note that changes in gumminess as affected by $CaSO_4$ concentration were dependent on TSPP level. At 0.12% TSPP, lowering $CaSO_4$ concentration resulted in increased gumminess (Fig. 3c). A reversed trend was exhibited at 0.18% TSPP (Fig. 4c), at which low gumminess would result from reducing $CaSO_4$ concentration.

Attaining the optimum treatment combinations

We previously reported that the instrumental fracturability, hardness and gumminess correlated (R = 0.65–0.74) with sensory scores of texture notes on simulated baked sweetpotatoes (Truong and Walter, 1994). Though correlations were about marginal to be used as predictors of sensory scores as stated by Bourne (1982), we used those parameters to develop optimum formulations with textural characteristics of a control. The following TPA values were within two standard deviations of means for the control, the 'Jewel' baked roots (n = 30): fracturability, 2.3–6.0N, hardness, 6.3–11.0N and gumminess, 0.4–1.0N. These values were used to set constraints for TPA parameters of the formulated sweetpotato. The shaded areas (Fig. 3a, 3b, 3c, 4a, 4b, 4c) represent values for respective TPA parameters corresponding to limits specified. Figure 3d was obtained by super-imposing the 0.12% TSPP contour maps of fracturability (Fig. 3a), hardness (Fig. 3b) and gumminess (Fig. 3c). In the same manner, Figure 4d was generated by overlaying the 0.18% contour maps (Fig. 4a, 4b, 4c). The shaded regions (Fig. 3d, 4d) represent all treatment combinations that would result in products with textural characteristics within the limits of baked sweetpotato roots. At 0.12% TSPP, the optimum formulations should contain: alginate, 0.20–0.25% and $CaSO_4$, 0.40–0.70%. At 0.18% TSPP, the alginate and $CaSO_4$ levels should be shifted to 0.20–0.55% and 0.22–0.42%, respectively.

Note that T-12 and T-5 (Table 1) fall within the overlapping regions identified in Fig. 3d and 4d, respectively.

Product acceptability

Samples of T-5, T-12, and F-0.2Alg, together with the baked roots, were subjected to acceptability sensory tests. Color, flavor, texture, and overall acceptability of the baked roots were scored at 7.1, 6.2, 6.9, and 6.4, respectively. The T-5 and T-12 formulations scored the same ($P < 0.05$) for color (7.4–7.5), flavor (6.0–6.7), texture (6.6–6.9), and overall acceptability (6.2–6.8). However the F-0.2Alg samples had the lowest scores for flavor (5.2), texture (6.2), and overall acceptability (5.5), which were different from the control. Several panelists reported a slightly bitter after-taste in the F-0.2Alg formulation. This was probably attributable to its high level (0.56%) of calcium sulfate.

Product color

The baked roots had L, a, and b values of 59.7, 21.7, and 45.3, respectively, similar to values previously reported (Truong and Walter, 1994). The beta-carotene content of baked 'Jewel' roots has been reported as high as 6.26–7.99 mg/100g sample (Wu et al., 1991). The T-5, T-12, and F-0.2Alg formulations had the same values for L (58.7–59.1), a (21.2–21.6), and b (38.8–39.3). The difference in degree of lightness (L value) and redness (a values) between formulated samples and baked roots was not significant ($P < 0.05$). However, the b values for the formulated were significantly lower than those for roots. Thus, restructured products had a lower intensity of yellowness than baked roots.

CONCLUSIONS

THE ALGINATE/CALCIUM SYSTEM is excellent for texturizing sweetpotato puree. The restructured system required minimal preparation and yet had the textural and flavor acceptability equal to traditionally baked sweetpotatoes. Moreover, such texturization could be applied to produce other types of processed products from sweetpotatoes. This research demonstrates the application of response surface statistical design together with instrumental texture profile parameters to attain optimum formulations for alginate-texturized products. Using this method, the number of samples subjected to sensory evaluation can be substantially reduced.

REFERENCES

Bourne, M.C. 1978. Texture profile analysis. Food Technol. 32: 62.

Bourne, M.C. 1982. *Food Texture and Viscosity: Concept and Measurement*, p. 265. Academic Press, New York.

Cochran, W.G. and Cox, G.M. 1957. *Experimental Design*, 2nd ed. John Wiley and Sons, NY.

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.

Draper, N.R. and Smith, H. 1981. *Applied Regression Analysis*, John Wiley and Sons, Inc., New York.

Gindler, E.M. and King, G.D. 1972. Rapid colorimetric determination of calcium in biologic fluids with methylthymol blue. Amer. J. Clin. Path. 58: 376-382.

Hannigan, K. 1983. Many possibilities for structured fruit. Food Eng. 55: 48.

Hoover, M.W., Walter, W.M. Jr., and Giesbrecht, F.G. 1983. Method of preparation and sensory evaluation of sweetpotato patties. J. Food Sci. 48: 1568-1569.

Imeson, A. 1990. Applications of alginates. In *Gums and Stabilizers for the Food Industry*, G.O. Phillips, D.J. Wedlock, and P.A. Williams (Ed.), Vol. 5, p. 553-562. Pergamon Press, Oxford, UK.

Johnson, R.C., Muller, T.S., Romans, J.R., Costello, W.J., and Jones, K.W. 1990. Effects of algin/calcium and adipic acid concentration on muscle-juncture formation. J. Food Sci. 55: 906-910, 914.

Kaletunc, G., Nussinovitch, A., and Peleg, M. 1990. Alginate texturization of highly acid fruit pulps and juices. J. Food Sci. 55: 1759-1761.

Kays, S.J. 1992. The chemical composition of the sweetpotato. In *Sweetpotato Technology for the 21st Century*, W.A. Hill, C.K. Bonsi, and P.A. Loretan (Ed.), p. 201-262. Tuskegee University, AL.

Luh, N., Karel, M., and Flink, J.M. 1976. A simulated fruit gel suitable for freeze dehydration. J. Food Sci. 41: 89-93.

Mandigo, R.W. 1986. Structuring of muscle foods. Food Technol. 40: 85.

Means, W.M., Clarke, A.D., Sofos, J.N., and Schmidt, G.R. 1987. Binding, sensory and storage properties of algin/calcium structured beef steaks. J. Food Sci. 52: 252-257.

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.

Mouquet, C., Dumas, J.C., and Guilbert, S. 1992. Texturization of sweetened mango pulp: optimization using response surface methodology. J. Food Sci. 57: 1395-1400.

Mullen, K. and Ennis, D.M. 1979. Rotatable designs in product development. Food Technol. 33(7): 74-80.

Nussinovitch, A. and Peleg, M. 1990. Mechanical properties of a raspberry product texturized with alginate. J. Food Proc. Preserv. 14: 267-278.

Pak, P.K. 1982. Development of frozen sweetpotato patty suitable for restaurant handling. M.S. thesis, Mississippi State Univ., Mississippi State, MS.

Pelaez, C. and Karel, M. 1981. Improved method for preparation of fruit simulating alginate gels. J. Food Proc. Preserv. 5: 63.

Picha, D.H. 1985. Crude protein, minerals and total carotenoids in sweetpotatoes. J. Food Sci. 50: 1768-1769.

SAS Institute, Inc. 1989. *SAS/STAT User's Guide*, SAS Institute, Inc., Cary, NC.

Schmidt, G.R. and Means, W.J. 1986. Process for preparing algin/calcium gel structured meat product. U.S. Patent 4,603,054.

—Continued on page 1074

*RESTRUCTURED SWEET POTATOES. . .*From page 1059

Shand, P.J., Sofos, J.N., and Schmidt, G.R. 1993. Properties of algin/calcium and salt/phosphate structured beef rolls with added gums. J. Food Sci. 58: 1224-1230.

Sime, W.J. 1984. The practical utilization of alginates in food gelling systems. In *Gums and Stabilizers for the Food Industry*, G.O. Phillips, D.J. Wedlock, and P.A. Williams (Ed.), Vol. 2, p. 177-188. Pergamon Press, Oxford, UK.

Trout, G.R., Chen, C.M., and Dale, S. 1990. Effect of calcium carbonate and sodium alginate on the textural characteristics, color and color stability of restructured pork chops. J. Food Sci. 55: 38-42.

Truong, V.D. and Walter, W.M. Jr. 1994. Physical and sensory properties of sweetpotato puree texturized with cellulose derivatives. J. Food Sci. 59: 1175-1180.

Walter, W.M. Jr. and Hoover, M.W. 1984. Effect of pre-processing storage conditions on the composition, microstructure, and acceptance of sweet-potato patties. J. Food Sci. 49: 1258.

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.

Ms received 11/14/94; revised 5/8/95; accepted 5/18/95.

We express our appreciation to Mrs. Faye L. Childers, Dept. of Statistics, North Carolina State Univ., for technical assistance in use of Statistical Analysis System.

Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the USDA or North Carolina Agricultural Research Service, nor does it imply approval to the exclusion of other products that may be suitable.