Quality Characteristics of Restructured Beef Steaks Manufactured by Various Techniques

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ABSTRACT

Beef (9–11% fat) was restructured with each of six mechanical treatments including chunking, fiberizing, slicing, chunking + slicing, slicing + water, and tenderizing each in combination with addition of 0.5% sodium chloride (salt)/0.5% phosphate, 0.5% Na-alginate/0.5% Ca-lactate, 0.5% Na-pectate/0.5% Ca-lactate, or no additives (control). Beef steaks restructured with salt/phosphate had lower ($P<0.05$) purge losses, higher binding force and bind scores than control products. Steaks restructured with Na-alginate/Ca-lactate had lower cooking losses and higher bind scores than controls. Use of Na-pectate/Ca-lactate did not improve ($P>0.05$) purge loss, cooking loss, binding force or sensory properties. Chunked meat or mixtures of chunked and sliced meats in combination with salt/phosphate or Na-alginate/Ca-lactate resulted in steaks with acceptable bind and textural properties.

Key Words: restructured, beefsteak, lactate, alginate, pectate

INTRODUCTION

RESTRUCTURING TECHNOLOGY makes it possible to produce value-added meat products from low quality cuts. A wide variety of raw materials such as chuck muscles (Recio et al., 1987; Mann et al., 1990), beef riblifter (Ensor et al., 1990), shoulder clods (Liu et al., 1990), lamb (Field et al., 1984), mutton (Prasad et al., 1987), pork (Huffman et al., 1987; Trout et al., 1990), turkey (Ernst et al., 1989; Ensor et al., 1989) and chicken (Xiong and Brekke, 1991) have been used to produce restructured products. Traditionally, salt and phosphate have been used in restructured meat products because of beneficial effects on cohesion, cook yield, juiciness, and flavor (Clarke et al., 1987; Mann et al., 1989; Wheeler et al., 1990, Craig et al., 1991; Liu et al., 1992).

Consumer markets are demanding low-sodium meat products. Thus, partial replacement or substitution of sodium chloride with other binding agents may maintain or improve quality of restructured meat products while adapting to market needs. Some restructuring techniques do not use salt and phosphate to facilitate binding, relying on mechanical treatments such as thin slicing (Bradshaw et al., 1990; Cohen, 1990) with chunking (Huffman, 1981), kneading (Gagliardi, 1988) or ultrathin slicing (Fradin, 1991), and realigning muscle fibers (Guenther, 1989; Gibson, 1991). Some have used addition of binding agents such as Na-alginate/Ca-lactate (Means and Schmidt, 1986; Schmidt and Means, 1986), fibrinogen/thrombin (Paardekooper and Wijngaards, 1988), milk/egg/cracker (Polancic, 1990), and surimi-like materials prepared from beef by-products (Kenney et al., 1992). Sodium-pectate/Ca-lactate gels may be a potential binding system. Pectate, as well as alginate, can be made into gels in the presence of calcium ions at room temperature and has been used as a gelling agent in canned meat products (Hughes et al., 1980). Because of the variety of processing systems, restructured steaks may have widely variable sensory properties. Our objective was to evaluate several restructuring techniques including mechanical treatments such as chunking, tenderizing and slicing; and various restructuring ingredients such as salt/phosphate, Na-alginate/Ca-lactate and Na-pectate/Ca-lactate for production of restructured beef steaks.

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MATERIALS & METHODS

Sample preparation

Beef riblifter meat (NAMP #109B; Beef Rib, Blade Meat, 9–11% fat) was obtained from a local meat packing plant (Monfort Inc., Greeley, CO) and was used to evaluate six mechanical processes for restructuring. These included (1) chunking, (2) fiberizing, (3) tenderizing, (4) slicing, (5) chunking-slicing, and (6) slicing+water. Three binding agents included (1) 0.5% salt (NaCl)/0.5% phosphate (Heller's soluble phosphate WJ-0052, Heller Seasonings and Ingredients Inc., Bedford Park, IL), (2) 0.5% Na-alginate/0.5% encapsulated calcium lactate (Kelco, Chicago, IL) and (3) 0.5% Na-pectate (Sigma Chemical Co., St. Louis, MO)/0.5% encapsulated calcium lactate (Kelco, Chicago, IL) and a control (no additives). Thus, 24 treatments were studied. Usage levels (0.5%) of salt, phosphate, Na-alginate and Ca-lactate were based on previous research (Raharjo et al., 1994). Na-pectate was also incorporated at 0.5% to facilitate comparisons between treatments.

Chunked meat was prepared by grinding through a plate with 2.5 cm diameter openings (Hobart Mfg. Co., Troy, OH) without a cutting blade, providing relatively large chunks of meat with irregular shapes. Fiberized meat was obtained by manually slicing the meat with a knife into strands (1.5 cm × 1.5 cm and 10–20 cm long) parallel to the muscle fibers. Tenderized meat was obtained by passing 200–250 g portions through a blade tenderizer (Steakmaster model 401, Hobart-Federal Engineering Corp., Minneapolis, MN) twice (parallel and perpendicular to the muscle fiber). Sliced meat (8 mm thick) was prepared by slicing soft frozen meat with a meat slicer (Hobart Mfg. Co., Troy, OH). Chunked+sliced treatments consisted of 75% chunked and 25% sliced meat, while sliced+water treatments consisted of 90% sliced meat and 10% added water. Each batch (1250 g) of meat was mixed with binding agents for 2 min in a mixer (model K45SS, KitchenAid Inc., St. Joseph, MI) at a speed setting of 2. The mixture was placed in plastic bags (15 cm × 51 cm), sealed under vacuum (Multivac, Allgäu, Germany) and manually formed into logs (diameter 9 cm, length 35 cm). Meat logs were initially placed in a cooler at 4°C for 6 hr to provide adequate time for formation of alginate/calcium and pectate/calcium gels and subsequently stored in a freezer at −20°C for 48 hr prior to slicing into steaks (1.9 cm thick). Restructured beef steaks were individually vacuum-packaged and stored frozen at −20°C for ≈ 1 wk before further evaluation.

Purge loss

Three frozen restructured beef steaks from each treatment, individually vacuum-packaged, were thawed at 4°C. After 24 hr, steaks were removed from packages and surfaces were manually wiped with a paper towel to remove visible exudate. Purge was calculated as weight loss divided by initial weight, expressed as percentage.

Cooking loss

Three frozen restructured beef steaks from each treatment were tempered for 1 hr at 24–25°C prior to cooking on an Open Hearth Broiler™ (Farberware, Yonkers, NY) for 11 min on one side and another 10 min on the other side until internal temperature ≈ 71°C was reached. Cooking loss was calculated as weight loss due to cooking divided by initial weight of raw steak, expressed as percentage.

Table 1—Purge (%) loss of vacuum-packaged raw restructured beef steaks after thawing at 4°C for 24 hr[z]

Treatment	No additives (Control)	0.5% Salt (NaCl) 0.5% Phosphate	0.5% Na-Alginate 0.5% Ca-lactate	0.5% Na-Pectate 0.5% Ca-lactate
Chunked	5.3 ± 0.9^{Aa}	0.9 ± 0.7^{Ba}	4.3 ± 1.1^{Aa}	5.6 ± 0.6^{Ab}
Fiberized	4.0 ± 1.3^{Aa}	0.8 ± 0.2^{Ba}	3.5 ± 0.9^{ABa}	5.6 ± 1.2^{Ab}
Sliced	4.7 ± 0.3^{Aa}	0.9 ± 0.1^{Ba}	4.9 ± 0.7^{Aa}	5.6 ± 1.2^{Ab}
Sliced + chunked	6.3 ± 0.6^{Aa}	0.8 ± 0.3^{Ca}	3.7 ± 0.7^{Ba}	6.6 ± 0.8^{Ab}
Sliced + water	11.0 ± 1.7^{Ab}	1.9 ± 0.7^{Ca}	6.2 ± 1.0^{Ba}	9.7 ± 1.0^{Aa}
Tenderized	4.1 ± 0.4^{Aa}	0.9 ± 0.2^{Ba}	3.4 ± 0.7^{Aa}	4.5 ± 0.6^{Ab}

[A–C] Means with different superscript within the same row are significantly ($P<0.05$) different.
[a–b] Means with different superscript within the same column are significantly ($P<0.05$) different.
[z] Expressed as mean ± standard deviation.

Table 2—Cooking loss (%) of restructured beef steaks[z]

Treatment	No additives (Control)	0.5% Salt (NaCl) 0.5% Phosphate	0.5% Na-Alginate 0.5% Ca-lactate	0.5% Na-Pectate 0.5% Ca-lactate
Chunked	34.1 ± 1.9^{Ab}	30.2 ± 0.7^{ABab}	25.2 ± 2.6^{Ba}	34.4 ± 3.2^{Aa}
Fiberized	33.3 ± 0.5^{Ab}	33.5 ± 1.0^{Aa}	25.7 ± 4.9^{Ba}	32.3 ± 1.9^{ABa}
Sliced	34.9 ± 2.4^{Aab}	28.0 ± 2.8^{Bb}	29.1 ± 2.2^{ABa}	32.3 ± 1.2^{ABa}
Sliced + chunked	36.5 ± 1.3^{Aab}	31.1 ± 1.3^{Bab}	28.2 ± 0.9^{Ca}	33.7 ± 0.8^{ABa}
Sliced + water	39.5 ± 1.7^{Aa}	34.2 ± 2.5^{Aa}	33.3 ± 4.0^{Aa}	35.6 ± 1.5^{Aa}
Tenderized	33.5 ± 2.1^{Ab}	32.1 ± 1.6^{Aab}	26.1 ± 3.5^{Ba}	33.3 ± 0.7^{Aa}

[A–C] Means with different superscript within the same row are significantly ($P<0.05$) different.
[a–b] Means with different superscript within the same column are significantly ($P<0.05$) different.
[z] Expressed as mean ± standard deviation.

Binding force

Instrumental assessment was made on the degree to which particles of restructured steaks physically adhere to each other within the cooked product. We used a test cell and a 2 cm diameter steel ball probe (modification of Field et al., 1984) on a J.J. Lloyd tensile testing machine (Model T5002, Pacific Scientific, Santa Ana, CA), at 24–25°C. Settings were: load cell 100 N, sensitivity 1.0, and crosshead speed 110 mm/min. Three steaks (those used for cooking loss evaluation) from each treatment were tested. The peak height was measured (mm) and converted to Newtons.

Sensory evaluation

Five trained panelists evaluated the restructured steaks. Panelists were trained following the procedure of Means and Schmidt (1986). Steaks were cooked as described and served to panelists immediately after cooking. In every session, only six treatments, randomly selected, were evaluated. Each panelist was supplied with a plate, a steak knife, a fork, a glass of cold tap water, and a disposal cup. Panelists received ≈ 30g of steak from each treatment. They were asked to rinse their mouths with cold tap water before evaluating each sample. Restructured beef steaks were cut with a knife and received a score of 1 for very weak bind between meat chunks (comparable to a ground beef patty), to 6 for very strong bind (comparable with intact muscle steak). Juiciness (score 1: very dry to 6: very juicy), flavor (score 1: very undesirable to 6: very desirable), texture (score 1: ground beef-like texture to 6: steak-like texture) were also evaluated. Because this was a trained panel, panelists were instructed to base flavor desirability scores on presence of any off-flavors associated with the restructured steak, instead of personal preference. Uniformity of interior color of the cooked steak was also evaluated. Particle to particle variation (color) can exist in restructured meat products. A score of 1 indicated very little cooked color uniformity, a score of 6 indicated very good cooked color uniformity.

Statistical analysis

The experiment was replicated twice with meat from a separate box and triplicate measurements were conducted in each replicate. Purge, cook loss, binding force and sensory evaluation data were presented as means along with standard deviations. Significant differences among treatments within each type measurement were determined by analysis of variance. Treatment means were separated by Tukey's test (Steel and Torrie, 1980) when a significant ($P<0.05$) F-test for main effects was found.

RESULTS & DISCUSSION

Purge loss

Beef steaks restructured with salt/phosphate had lower ($P<0.05$) purge than steaks restructured with no additives (control) (Table 1). Addition of NaCl typically weakens interaction between oppositely charged groups of myofibrillar proteins, resulting in increased swelling and water holding capacity (Hamm, 1986). The addition of Na-pectate/Ca-lactate had no ($P>0.05$) effect on purge as compared with controls. Purge in steaks restructured with Na-alginate/Ca-lactate was not ($P>0.05$) different from controls, except for sliced+chunked and sliced+water treatments which had less ($P<0.05$) purge. Mechanical treatment had no ($P>0.05$) effect on purge in steaks restructured with salt/phosphate or Na-alginate/Ca-lactate. Treatments containing 10% added water had higher ($P<0.05$) purge in steaks restructured with Na-pectate/Ca-lactate or no additives.

Cooking loss

Addition of Na-alginate/Ca-lactate reduced ($P<0.05$) cook loss, except for sliced and sliced+water treatments which were not different from corresponding controls (Table 2). Treatments formulated with salt/phosphate and sliced or sliced+chunked meat had lower ($P<0.05$) cooking loss than controls. Therefore, steaks restructured with salt/phosphate had higher ($P<0.05$) cook yields when they were prepared from sliced or sliced +chunked meat. Previous studies have indicated that use of salt and phosphate increased cook yield in restructured steaks (Mann et al., 1989; Wheeler et al., 1990, Craig et al., 1991). Cook loss or cook yield was related to cooking method (Quenzer and Donnelly, 1982), oven temperature, relative humidity, sample dimensions (Bengtsson et al., 1976) and internal temperature (Tanchotikul et al., 1989). Steaks prepared with no additives and added water had higher ($P<0.05$) cook losses than those prepared with chunked, fiberized or tenderized meats. Various mechanical treatments did not affect ($P>0.05$) cook loss when steaks were restructured using Na-alginate/Ca-lactate or Na-pectate/Ca-lactate.

Binding force

Beef steaks restructured with salt/phosphate had higher ($P<0.05$) binding force than controls (Table 3). This was in agreement with previous studies which reported that addition of salt (0.5 to 0.75%) and phosphate (up to 0.5%) were required to achieve satisfactory bind in restructured beef steaks (Coon et al., 1983). Salt and phosphate induce solubilization of myofibrillar proteins during mixing and this exudate serves as binding agent upon cooking (Ghavimi et al., 1987). Addition of Na-pectate/Ca-lactate did not improve ($P>0.05$) binding force com-

Table 3—Binding force^{y} (Newtons) of cooked restructured beef steaks^{z}

Treatment	No additives (Control)	0.5% Salt (NaCl) 0.5% Phosphate	0.5% Na-Alginate 0.5% Ca-lactate	0.5% Na-Pectate 0.5% Ca-lactate
Chunked	19.9 ± 1.2^{Ba}	48.0 ± 9.4^{Aa}	36.7 ± 1.3^{ABab}	27.9 ± 13.3^{ABa}
Fiberized	31.5 ± 12.2^{Ba}	54.9 ± 5.8^{Aa}	31.2 ± 10.1^{Bab}	28.3 ± 3.8^{Ba}
Sliced	19.5 ± 2.4^{Ba}	55.7 ± 14.2^{Aa}	24.9 ± 2.6^{Bb}	15.2 ± 3.8^{Ba}
Sliced + chunked	29.6 ± 9.1^{Ba}	56.1 ± 14.4^{Aa}	44.0 ± 4.2^{ABa}	23.1 ± 7.7^{Ba}
Sliced + water	15.1 ± 0.9^{Ca}	47.6 ± 5.9^{Aa}	26.0 ± 2.4^{Bb}	18.4 ± 2.0^{BCa}
Tenderized	20.8 ± 2.9^{Ba}	46.8 ± 10.5^{Aa}	28.7 ± 5.8^{Bb}	14.8 ± 2.2^{Ba}

A–C Means with different superscript within the same row are significantly ($P<0.05$) different.
a–b Mean with different superscript within the same column are significantly ($P<0.05$) different.
y Force (Newtons) to penetrate cooked steak with a 2 cm diameter steel ball.
z Expressed as mean ± standard deviation.

Table 4—Sensory evaluation^{y} of cooked restructured beef steaks^{z}

Treatment	No additives (Control)	0.5% Salt (NaCl) 0.5% Phosphate	0.5% Na-Alginate 0.5% Ca-lactate	0.5% Na-Pectate 0.5% Ca-lactate
		Juiciness		
Chunked	3.6 ± 1.5^{ABa}	5.0 ± 0.0^{Aa}	5.0 ± 0.0^{Aa}	2.8 ± 0.4^{Ba}
Fiberized	3.2 ± 1.3^{Aa}	4.2 ± 1.1^{Aa}	4.8 ± 0.8^{Aa}	3.8 ± 1.1^{Aa}
Sliced	3.0 ± 0.7^{Aa}	3.6 ± 0.9^{Aa}	4.6 ± 0.9^{Aa}	3.8 ± 1.1^{Aa}
Sliced + chunked	3.8 ± 0.8^{Aa}	4.8 ± 0.8^{Aa}	5.0 ± 1.2^{Aa}	3.4 ± 1.1^{Aa}
Sliced + water	3.4 ± 1.1^{Ba}	5.0 ± 0.0^{Aa}	5.4 ± 0.5^{Aa}	3.2 ± 1.1^{Ba}
Tenderized	3.4 ± 1.1^{Aa}	4.8 ± 0.8^{Aa}	4.4 ± 0.5^{Aa}	4.4 ± 1.1^{Aa}
		Bind		
Chunked	1.4 ± 0.5^{Ba}	5.0 ± 0.7^{Aa}	5.6 ± 0.5^{Aa}	1.6 ± 0.9^{Ba}
Fiberized	1.6 ± 1.3^{Ba}	4.8 ± 0.4^{Aa}	4.2 ± 1.1^{Aab}	1.6 ± 0.5^{Ba}
Sliced	1.4 ± 0.9^{BCa}	5.0 ± 0.7^{Aa}	3.2 ± 1.6^{ABb}	1.2 ± 0.4^{Ca}
Sliced + chunked	2.0 ± 1.0^{Ba}	5.4 ± 0.5^{Aa}	4.0 ± 1.6^{Aab}	2.0 ± 0.7^{Ba}
Sliced + water	2.4 ± 0.5^{BCa}	5.0 ± 0.0^{Aa}	3.6 ± 1.1^{Bab}	1.6 ± 0.5^{Ca}
Tenderized	1.2 ± 0.4^{Ba}	5.0 ± 0.7^{Aa}	4.2 ± 0.8^{Aab}	1.4 ± 0.5^{Ba}
		Flavor		
Chunked	3.8 ± 1.3^{ABa}	4.8 ± 1.1^{Aa}	4.6 ± 1.1^{Aa}	2.0 ± 1.4^{Ba}
Fiberized	3.4 ± 1.1^{Aa}	4.8 ± 0.8^{Aa}	3.4 ± 1.7^{Aa}	3.2 ± 0.4^{Aa}
Sliced	3.6 ± 1.1^{Aa}	4.4 ± 0.5^{Aa}	4.4 ± 0.5^{Aa}	3.2 ± 1.1^{Aa}
Sliced + chunked	4.0 ± 1.0^{Aa}	4.2 ± 0.8^{Aa}	3.2 ± 1.5^{ABa}	1.8 ± 1.3^{Ba}
Sliced + water	4.2 ± 0.8^{Aa}	4.2 ± 0.8^{Aa}	3.6 ± 0.5^{Aa}	2.8 ± 0.8^{Aa}
Tenderized	3.8 ± 0.4^{ABa}	5.4 ± 0.9^{Aa}	3.2 ± 1.8^{Ba}	2.8 ± 1.3^{Ba}
		Texture		
Chunked	3.2 ± 0.8^{BCab}	4.6 ± 0.9^{ABa}	5.0 ± 1.2^{Aa}	2.4 ± 0.5^{Ca}
Fiberized	4.2 ± 0.8^{Aa}	4.8 ± 0.4^{Aa}	4.4 ± 1.3^{Aa}	3.6 ± 0.9^{Aa}
Sliced	3.2 ± 0.8^{ABab}	4.4 ± 1.3^{Aa}	3.2 ± 1.3^{ABa}	2.4 ± 0.5^{Ba}
Sliced + chunked	3.6 ± 1.1^{Aab}	4.4 ± 0.9^{Aa}	3.6 ± 1.8^{Aa}	2.2 ± 0.8^{Aa}
Sliced + water	3.2 ± 1.6^{Aab}	4.6 ± 1.1^{Aa}	4.0 ± 0.7^{Aa}	3.2 ± 1.6^{Aa}
Tenderized	1.8 ± 0.8^{Ab}	3.6 ± 1.9^{Aa}	2.8 ± 0.4^{Aa}	2.0 ± 0.0^{Aa}

A–C Means with different superscript within the same row are significantly ($P<0.05$) different.
a–b Means with different superscript within the same column are significantly ($P<0.05$) different.
y Juiciness (1: very dry and 6: very juicy), bind (1: very weak bind and 6: very strong bind). Flavor (1: very undesirable and 6: very desirable) and texture (1: ground beef-like texture and 6: whole muscle steak-like texture).
z Expressed as mean + standard deviation.

pared to controls. Although Na-pectate could form a gel with calcium (Hughes et al., 1980), a cohesive gel did not form under our conditions. The mechanical strength of calcium pectate gel is, in part, determined by the degree of esterification of pectin and the pH of the mixture (Gemeiner et al., 1991). Further study is needed to determine proper types of pectate and calcium sources and appropriate conditions for pectate/calcium gel formation. Use of Na-alginate/Ca-lactate increased ($P<0.05$) binding force in steaks prepared from sliced meat with added water only, as compared with corresponding controls. As a result of varying shapes and sizes of meat particles, binding force in restructured steaks could show relatively large variations (Berry and Civille, 1986). Increasing the level of Na-alginate (from 0.5% to 1.0%) might increase the binding force as reported by Clarke et al. (1988) and Ensor et al. (1989). The maximum level of Na-alginate and Ca-lactate allowed in restructured meat products is 1.5% (USDA FSIS, 1986). The various mechanical treatments had no ($P>0.05$) effect on binding force, except for steaks restructured with Na-alginate/Ca-lactate and a mixture of sliced and chunked meat. These had significantly higher binding force than that of steaks prepared with sliced, sliced+water and tenderized meat. Preparation of restructured steaks by combining meat cuts with different shapes had been reported (Huffman 1981 and Cohen 1990).

Sensory evaluation

Steaks restructured with Na-pectate/Ca-lactate had similar ($P>0.05$) juiciness as those restructured with no additives (control) (Table 4). Those restructured with salt/phosphate or Na-alginate/Ca-lactate also had similar ($P>0.05$) juiciness, except for steaks prepared with added water, which were juicier than controls. This agreed with Ensor et al. (1989) who reported that addition of Na-alginate/Ca-lactate binder with no added water did not change ($P>0.05$) juiciness of restructured turkey meat as determined by panelists. All mechanical treatments had no ($P>0.05$) effect on cooked product juiciness. However, addition of water (10%) along with salt/phosphate or Na-alginate/Ca-lactate may be useful to increase restructured steak juiciness.

Use of Na-alginate/Ca-lactate improved ($P<0.05$) bind scores of restructured beef steaks as compared with controls. Panelists were more effective in assessing this than was the instrumental method. Steaks restructured with salt/phosphate had higher ($P<0.05$) bind scores than controls. This was in agreement with instrumental binding force results. Steaks restructured with Na-pectate/Ca-lactate were not different from the control for bind.

Mechanical treatment had no ($P>0.05$) effect on flavor of steaks restructured with no additives, salt/phosphate, Na-alginate/Ca-lactate or with Na-pectate/Ca-lactate. Thus, addition of water (10%) did not affect the flavor of restructured beef steaks. Addition of Na-pectate/Ca-lactate tended to decrease flavor acceptability of restructured steaks. The source of objectionable flavor may be the Na-pectate, or a product of a reaction between Na-pectate and meat components. The use of Na-alginate/Ca-lactate as restructuring components did not (P>0.05) affect flavor acceptability as compared to controls. Previous studies have indicated that the flavor of restructured beef (Means et al., 1987) or turkey meat (Ensor et al., 1989) prepared with Na-alginate/Ca-lactate binder (0.5 to 1.0%) did not differ (P>0.05) from controls. Similarly, panelists found no differences in flavor desirability between steaks formulated with salt/phosphate and controls.

Texture of restructured steaks could range from "ground beef-like" to "steak-like." The texture of steaks restructured with salt/phosphate or Na-pectate/Ca-lactate was not different (P>0.05) from the control. Addition of Na-alginate/Ca-lactate also had no (P>0.05) effect on texture of the restructured steak, except for the chunked treatment which was evaluated as superior to the control. The various mechanical treatments had no effect (P>0.05) on texture of steaks formulated with salt/phosphate, Na-alginate/Ca-lactate or Na-pectate/Ca-lactate. In control treatments where no additives were used, tenderized meat resulted in steaks with ground beef-like texture. Use of fiberized meat seemed to result in desirable steak-like texture. Berry et al. (1987) also recommended larger sized meat pieces to improve product texture. Sliced meat may also be used in combination with chunked meat to improve product tenderness while maintaining acceptable texture. Various mechanical treatments and restructuring components did not significantly affect color uniformity (data not shown) of cooked restructured beef steaks. However, on a 6-point scale (1: very poor cooked color uniformity and 6: very good cooked color uniformity), color uniformity scores ranged from 3.2 to 4.2, 2.4 to 3.6, 3.6 to 5.0, and 2.6 to 4.0 for control, salt/phosphate, Na-alginate/Ca-lactate, and Na-pectate/Ca-lactate treatments, respectively.

Techniques to manufacture restructured meat products vary with respect to mechanical treatments and binding ingredients. Our results indicated that chunked meat or mixtures of chunked and sliced meats in combination with salt/phosphate or Na-alginate/Ca-lactate resulted in steaks with acceptable physical and sensory properties. Utilization of Na-pectate/Ca-lactate as binding ingredients did not improve quality of restructured beef.

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