Effects of Various Levels of Sodium Chloride and Hexametaphosphate on Restructured Beef Steaks During Cooler Storage

Paul A. Will*
Hyung Se Kim
Division of Range Animal Science, Sul Ross State University, Alpine, TX 79832

ABSTRACT

Restructured beef steaks were prepared from boneless chucks. This study evaluated the effects of salt, phosphate and length of cooler storage on restructured beef steaks. Samples were manufactured with four sodium chloride and phosphate combinations (treatments) 0% and 0%, 0% and 0.5%, 2% and 0%, and 2% and 0.5%. Water was added (3%) at the time of mixing. The product was formulated in a mixer for 15 minutes. The four treatments were passed through a patty machine (3/1 head) and then stored at 4°C for 0, 3, 6, and 10 days. Various quality attributes of restructured beef steaks were studied. Restructured beef steaks with salt had lower ($P<0.05$) water-holding capacity (WHC) values (higher water binding capacity) than controls or those manufactured with phosphate alone. The taste panelists detected significantly ($P<0.05$) improved juiciness and cohesiveness with 2% sodium chloride. Percent moisture and the Warner-Bratzler shear force values did not differ significantly among treatments or storage periods.

In recent years, much interest has been shown in the processing of lower value and tougher cuts of meat into higher value meat items. Current restructuring technologies offer new methods of beef chuck utilization which include the use of sodium chloride, phosphate and a variety of additional non-meat ingredients. These ingredients can be used to produce an increasing variety of portion-controlled meat products from the beef chuck that can be formed into different shapes with a desired texture and tenderness.

MATERIALS AND METHODS

Two-piece boneless vacuum packaged chucks (#115, National Association of Meat Purveyors, 1992) were used in this study. Three replications of the study were conducted. The muscles were ground through a coarse grinder plate (2.5 cm) and then through a fine plate (0.3 cm). The ground meat was placed in polyethylene bags and stored for 4 hours at 4°C. The meat formulation consisted of 90% lean and 10% fat with 3% water added. Analysis was determined by using a modified Babock analysis (AOAC, 1990). From this meat block the four separate treatments

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were formulated.

The four formulation treatments were 1) No added sodium chloride or phosphate (control), 2) 0.0% sodium chloride with 0.5% phosphate added, 3) 2.0% sodium chloride with 0.0% phosphate, and 4) 2.0% sodium chloride with 0.5% phosphate.

Each treatment was mixed 15 minutes in a Leland food mixer (Leland Detroit Co. Detroit, MI). The phosphate was a commercial grade sodium hexametaphosphate while the salt was a commercial grade of sodium chloride. Each bulk formulation was passed through a Hollymatic patty machine using a 3/1 head. These steaks were wrapped in plastic film and stored at 4°C until evaluated.

Proximate composition for moisture was determined in duplicate on the raw sample using the oven drying method (AOAC, 1975). The cooking procedure for all restructured steaks was in a Blodgett convection oven. All samples (sensory and objective measurements) were cooked to an internal temperature of 34°C before being turned and cooked to a final internal temperature of 68°C.

For sensory evaluation, a seven-member trained sensory panel (Gross and Stanfield, 1976) evaluated broiled restructured beef steaks. Each panel was randomly served samples from each treatment. The cooked restructured steaks were evaluated for appearance, flavor, cohesiveness, juiciness, and tenderness. An 8-point scale (8=excellent, 1=extremely poor) was used in evaluating product quality.

Water holding capacity (WHC) was determined by the filter paper press method, (high WHC values represent low WHC) as developed and used by Hamm (1960). Shear force (kg) was estimated with steaks from each formulation treatment and storage period. Steaks were placed in a Blodgett convection oven and were broiled to an internal temperature of 68°C. The cooked steaks were placed in a 2°C to 0°C cooler for 45 minutes before testing. This provided adequate firmness to better ensure uniform cores (Will and Henrickson, 1976). From each steak, three 1.25 cm diameter cores were taken at three pre-selected sites on the steak. Each core was sheared three times using the Warner-Bratzler Shear.

Data were analyzed by Analysis of Variance (Barr et al., 1979) using a completely random design (Steele and Torrie, 1980) with split-plot treatment arrangements. Where significant differences were found, means were separated by Duncan's multiple range test (Snedecor and Cochran, 1980). Significant differences were accepted at the 5% level.

RESULTS AND DISCUSSION

In this experiment, there was no difference ($P > 0.05$) in percent moisture between raw steak samples (Table 1). Likewise, phosphate data showed little influence on moisture retention (Cassidy, 1977).

Sensory panelists detected no difference ($P > 0.05$) for tenderness from restructured beef steak among treatments (Table 2), thus, the addition of sodium chloride and phosphate had slight effect on tenderness. Likewise, no significant differences ($P > 0.05$) in tenderness were detected among the formulations and treatments storage period. Tenderness scores remained relatively constant throughout the storage period.

Table 1. Raw meat percent moisture mean values by $NaCl/PO_4$ combinations and storage days. Means did not differ significantly ($P > 0.05$).

Treatment NaCl, PO_4	Cooler Storage (days)			
	0	3	6	10
0%, 0%	70.35	69.87	69.75	69.43
0%, 0.5%	70.50	70.34	70.31	69.93
2%, 0%	70.49	69.89	70.19	69.75
2%, 0.5%	70.63	69.53	69.96	69.84

Sensory panelists, however, detected differences ($P < 0.05$) in appearance, flavor, cohesiveness, and juiciness among restructured beef steak treatments. Restructured steaks with 2% sodium chloride and 0.5% phosphate were juicier, more flavorful and more cohesive than the other combinations. Juiciness and appearance scores were slightly increased by phosphate treatment. As previously stated, sensory panelists detected differences ($P < 0.05$) in appearance score between treatments (Table 2). However, the appearance score decreased ($P < 0.05$) over the storage time. Sodium chloride (2%) increased ($P > 0.05$) sensory panelists scores for cohesiveness. Siegel and Schmidt (1979) and Macfarlane et al., (1977) reported that NaCl is a primary factor in the development of this property. This product resembled a solid piece of meat in appearance and texture. Cohesiveness scores remained relatively consistent during cooler storage (Table 2).

Analysis of taste panel data indicated differences ($P < 0.05$) in juiciness scores between treatments for restructured beef steaks (Table 2). However, there was a tendency for sensory panelist scores for juiciness to decrease ($P < 0.05$) over the storage time (Table 2). Longer storage times for restructured beef steaks decreased flavor scores. This trend might indicate slight influences on oxidation during the storage period. This observation was previously reported by Okerman and Organisciak (1979).

All sensory factors (flavor, cohesiveness and juiciness) showed general improvement with the 2% sodium chloride, 0.5% phosphate combination. Neer and Mandigo (1977) also reported that panelists preferred restructured meat product containing sodium chloride and phosphate in comparison to the control.

Mean values of water-holding capacity (Table 3) showed that control and 0.5% phosphate samples had higher ($P > 0.05$) water-holding capacity (WHC) values than steaks containing sodium chloride. Juiciness increased at the 2% level of sodium chloride. This was expected since sodium chloride has been shown to increase water-holding capacity. These results agree with those reported by Neer and Mandigo (1977). Their study found that juiciness improved as percent of NaCl was increased in the cured pork product.

Table 2. Mean values of sensory evaluation by $NaCl/PO_4$ combinations and storage days.† Sensory evaluations were made with an 8-point scale (8=excellent, 1=extremely poor).

	%NaCl, %PO_4				Cooler storage (days)			
	0, 0	0, 0.5	2, 0	2, 0.5	0	3	6	10
Appearance† (color)	4.50‡a	4.87a	4.97a	5.39a	5.35a	5.40a	4.85a	3.92a
Flavor	4.00a	4.23a	5.40b	5.80b	4.51a	4.55a	4.79a	4.46a
Cohesiveness	3.70a	4.00a	5.43b	6.00b	3.56a	4.76a	5.42b	5.41b
Juiciness	3.77a	3.83a	4.90b	5.03b	3.67a	5.38b	5.37ab	5.35a
Tenderness	5.20a	4.73a	5.60a	5.83a	5.24a	5.40a	5.40a	5.75a

†n=7 for sensory evaluation.

‡Within a row, means from the various $NaCl/PO_4$ combinations or storage days followed by the same letter did not differ significantly ($P>0.05$).

Shear force values (Table 4) indicated no significant differences ($P > 0.05$) between treatment and storage period. Since these data were in agreement with sensory panel results, it was concluded that restructured steaks have acceptable tenderness.

Sodium chloride addition to restructured beef steaks increased sensory panel acceptability and water-holding capacity, whereas phosphate had little effect on sensory panel scores or percent moisture of the product. The combination of sodium chloride and phosphate improved the sensory properties over that of 0.5% phosphate or control steaks. Cooler storage for up to 10 days did not significantly affect the sensory properties, percent moisture, water-holding capacity or shear value in restructured beef steaks derived from the bovine chuck.

Table 3. Mean values of water-holding capacity (WHC) by $NaCl/PO_4$ combinations and storage days.†

Treatment	Cooler Storage (days)			
%NaCl, $\%PO_4$	0	3	6	10
0, 0	19.48‡a	20.32a	21.03a	22.26a
0, 0.5	20.84a	19.61a	19.87a	19.61a
2, 0	9.35b	11.03b	11.48b	10.58b
2, 0.5	11.35b	11.55b	13.16b	12.97b

†Ratio (cm^2) of total juice area to meat film area (high number indicates low WHC).
‡Within a column, means followed by the same letter did not differ significantly ($P > 0.05$).

Table 4. Mean values of Warner-Bratzler shear force (kg) by $NaCl/PO_4$ combinations and storage days. Means did not differ significantly ($P > 0.05$).

Treatment	Cooler Storage (days)			
NaCl, PO_4	0	3	6	10
0%, 0%	1.52	1.37	1.97	2.21
0%, 0.5%	1.40	1.39	1.78	1.77
2%, 0%	1.48	1.25	1.72	1.42
2%, 0.5%	1.41	1.47	1.49	1.41

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