Effects of Sodium Chloride, Sodium Hexametaphosphate And Freezer Time on Restructured Beef Chuck Steaks

Paul A. Will*
Gary L. Brown
Sul Ross State University, PO Box C-158, Alpine, TX 79832

ABSTRACT

This study evaluated the effects of sodium chloride, sodium hexametaphosphate and length of freezer storage on restructured beef chucks. One-third pound (151 g) ground beef chuck steaks were prepared from two piece boneless chucks. Four different sodium chloride (NaCl) and sodium hexametaphosphate (HMP) combinations were used: 0% NaCl, 0% HMP; 2% NaCl, 0% HMP; 0% NaCl, 0.5% HMP; and 2% NaCl, 0.5% HMP. While mixing the restructured product for 15 minutes, water was added at the 3% level. The four formulations were passed through a patty machine and then stored at a temperature of -20 °C for 0, 4, 8, and 12 week periods. Various quality attributes of restructured beef steaks were studied. The taste panelists detected a significant ($P<0.05$) improvement in tenderness, flavor and visual appearance with the 2% NaCl, 0.5% HMP treatment. Warner-Bratzler shear force values and the triangle differentiation tests indicated significant ($P<0.5$) differences between treatments.

The demand for retail cuts derived from the chuck portion of the beef carcass has declined drastically. Recent studies conducted by the American Livestock and Meat Board have identified consumer buying habits as changing and forcing demand for chuck retail cuts. Thus, interest has been shown in converting the lower valued, tougher cuts of meat into higher valued meat items.

Current restructuring technology offers alternative methods of preparation using NaCl, various phosphates and additional non-meat ingredients. These ingredients can be used to produce an increasing variety of portion controlled meat products that can be formed into different shapes with a desired texture and tenderness.

Restructured meat products may offer many benefits (Field, 1982) to compete in the retail market. Several such benefits are portion control, extended shelf life, convenience of preparation, economical means of utilizing the trim, and utilization of lower grade carcasses to form products of uniform quality (Barr et al., 1979). Thus, restructured beef chuck steaks are a positive alternative as opposed to the less desirable retail cuts of the chuck portion of the beef carcass.

The chuck portion of the beef carcass makes up nearly 30% by weight of the total carcass but only 22% of its value (Patterson and Parrish, 1986).

The objective of this study was to investigate the influence of NaCl, HMP, and freezer time on restructured steaks derived from the beef chuck.

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MATERIALS AND METHODS

Processing

The present research study was conducted at the Sul Ross State University Meat Science Laboratory in Alpine, Texas.

Two piece boneless vacuum packaged chucks were used to formulate three replications. Each chuck was randomly allocated into four groups and trimmed of excessive fat and connective tissue. Intact muscles were ground first through a coarse grinder plate (2.5 cm) and then ground through a fine grinder plate (0.3 cm). The ground muscle was then allowed to equilibrate overnight (no ingredients added). Each of these formulations were then tested for fat content using the modified Babcock Analysis (AOAC, 1990). The final product consisted of 85% lean and 15% fat. Three percent water was added to the final products. The additives used in the study, NaCl, HMP, and H_20, were food grade.

Additive treatments applied to restructured steaks were as follows: T1, restructured steaks prepared with 0.0% NaCl and 0.0% HMP; T2, restructured steaks prepared with 2.0% NaCl and 0.0% HMP; T3, restructured steaks prepared with 0.0% NaCl and 0.5% HMP; T4, restructured steaks prepared with 2.0% NaCl and 0.5% HMP.

All ingredients and ground meat treatments were combined and mixed for 15 minutes in a Leland Food Mixer. All non-meat ingredients were dissolved in water and added during the initial stages of mixing.

Immediately after mixing, each formulation treatment was passed through a Hollymatic Patty Machine, manufacturing three restructured steaks to a one pound ratio. The restructured beef chuck steaks were then individually wrapped in polyethylene bags and frozen at -20 °C. Products were then analyzed at 0, 4, 8, and 12 week intervals for sensory, visual and textural properties.

All steaks were cooked using a Blodgett convection oven. Prior to cooking, the oven was preheated to a temperature of 177 °C (350 °F). The restructured beef chuck steaks were then inserted and allowed to cook to an internal temperature of 61 °C (120 °F) before being flipped and cooked to a final internal temperature of 86 °C (170 °F). These temperature measurements were determined by inserting the thermometer into the center of each steak.

Test Procedures

A taste panel consisting of seven individuals was used to test the steaks. The panelists evaluated the color of the fresh meat product prior to cooking. Immediately after cooking, steaks were evaluated for tenderness, cooked color, flavor, and personal preference.

Three triangle differentiation surveys were given to panel members to determine their ability to distinguish treatments. The surveys were: Survey 1) 0.0% NaCl, 0.0% HMP vs 2.0% NaCl, 0.0% HMP; Survey 2) 0.0% NaCl, 0.0% HMP vs 0.0% NaCl, 0.5% HMP; Survey 3) 0.0% NaCl, 0.0% HMP vs 2.0% NaCl, 0.5% HMP.

Shear force (Kg) was estimated with steaks from each formulated treatment and storage period. Steaks were placed in a Blodgett convection oven. Steaks were broiled to an internal temperature of 86 °C (170 °F). The cooked steaks were wrapped and placed in a 2 °C cooler for 45 minutes before testing. This provided adequate firmness to ensure uniform cores (Will and Henrickson, 1976). From each

steak, five 0.25 cm cores were taken at five areas on each individual steak. Each core was sheared once and the average of the five measurements was recorded.

Data were treated by analysis of variance (Barr et al., 1979) using a completely random design (Steel 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). Treatments were characterized as the main effect with the storage time being the sub-unit. Data were analyzed using MSTAT (Nissen, 1986). Significant differences were accepted at the 5% level.

RESULTS AND DISCUSSION

The triangle differentiation test yielded data that were consistent throughout the study. There was a significant difference ($P<0.05$) in Survey 1 responses (Table 1), indicating that the taste panel could detect a difference between the product treated with 0.0% NaCl, 0.0% HMP and the product treated with 2.0% NaCl, 0.0% HMP. In Survey 2, no significant difference ($P>0.05$) between products was detected, indicating that HMP alone has no effect on flavor or appearance when integrated into a meat product. Survey 3 indicated a difference ($P<0.05$) between the control (0.0%, NaCl, 0.0% HMP) and the treatment with 2.0% NaCl, 0.5% HMP. This agrees with Mandigo et al. (1973) that NaCl improves flavor.

Shear force values are presented in Table 2. The control (T1) with no additives or preservatives, proved to be different ($P<0.05$) from other treatments in the first month of shear force testing. However, the control product stabilized after about 2 months experimentation. The shear strength test illustrated no difference ($P>0.05$) between T1 and T3 3 at the 4 and 8 week periods. However, at the 12 week period, the control product was significantly ($P<0.05$) less tender.

Table 1. Mean correct and incorrect responses in triangle differentiation test to determine panel member's ability to detect taste differences between products.

% NaCl, %HMP	Correct responses	Incorrect responses
Survey 1 0.0%NaCl, 0.0%HMP vs 2.0%NaCl, 0.0%HMP	104 (93%)	8 (7%)
Survey 2 0.0%Nacl, 0.0%HMP vs 0.0%NaCl, 0.5%HMP	58[a] (52%)	54[a] (48%)
Survey 3 0.0%NaCl, 0.0%HMP vs 2.0%NaCl, 0.5%HMP	101 (90%)	11 (10%)

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

Table 2. Mean shear force (kg) as affected by NaCl and HMP treatments and freezer storage time. The higher number indicates the tougher product.

Treatment	NaCl, HMP	Freezer storage			
		0 weeks	4 weeks	8 weeks	12 weeks
T1	0.0%, 0.0%	3.74	2.41	2.425[a]	2.737
T2	2.0%, 0.0%	2.32	1.73[a]	2.353[a]	2.134[a]
T3	0.0%, 0.5%	2.96[a]	2.31	2.109	1.840[a]
T4	2.0%, 0.5%	2.80[a]	1.73[a]	1.50	1.256

[a]Means in a column followed by the same letter are not significantly different ($P<0.05$).

Treatment 2 (2.0% NaCl, 0.0% HMP) was the most tender steak at the fresh product state and the 4 week period. However, at the 8 and 12 week periods, T4 produced the most tender steaks (Table 2).

Shear force increased linearly with time with the exception of T4. Significant differences in shear force existed between each individual treatment storage time. As shown in Table 2, shear strength was affected by the addition of NaCl and HMP.

With all four treatments, sensory panel tenderness was directly proportional to shear force values. All treatments were evaluated on a scale from 1 (extremely poor) to 8 (excellent) (Table 3). The product from T1 was preferred over T3 the first month and then became the lowest evaluated in tenderness throughout the remainder of the study. Treatment 2 was relatively tender and continued to be stable at the 4 and 8 week periods. At the end of the 12 week period the tenderness evaluation dropped. Treatment 3 was a relatively tender product over time. Treatment 4 was the most preferred in tenderness compared to all other products. Throughout the experiment, T4 was significantly ($P<0.05$) higher in tenderness evaluation. The observations in this study did not agree with Neer and Mandigo (1977) that a product becomes tougher with time.

Table 3. Mean tenderness values as affected by NaCl and HMP treatments and freezer storage time. Higher numbers indicate the more tender product.

Treatment		Freezer storage			
NaCl	HMP	0 weeks	4 weeks	8 weeks	12 weeks
0.0%	0.0%	5.321[a]	4.643[a]	4.179[a]	4.394
2.0%	0.0%	5.357[a]	4.857[a]	4.965	4.822[a]
0.0%	0.5%	4.857	4.322	4.179[a]	4.857[a]
2.0%	0.5%	5.536[a]	4.750[a]	5.036	5.821

[a]Means in a column followed by the same letter are not significantly different ($P<0.05$).

Sensory panelists detected significant differences ($P<0.05$) for appearance and flavor among restructured beef chuck steak treatments (Table 4). The restructured steaks from T4 produced the most eye appealing product. This is in agreement with Pepper and Schmidt (1975). Treatments 1, 2 and 3 resulted in decreasing scores over storage time, whereas T4 resulted in a significant increase.

Analysis of the taste panel data indicated significant differences ($P<0.05$) in flavor scores between treatments for restructured beef chuck steaks (Table 5). There was a significant ($P<0.05$) tendency for flavor scores to decrease over storage time. These data are in agree with Miller et al. (1985). Treatment 4 proved to be the most desirable product for flavor. Pepper and Schmidt (1975) also reported that sensory panelists preferred restructured meat products containing NaCl and phosphate in comparison to 0.0% NaCl, 0.0% PO_4.

Table 4. Mean appearance values as affected by NaCl and HMP treatments and by freezer storage time. Higher values indicate greater visual appeal.

Treatment NaCl HMP	Freezer storage 0 weeks	4 weeks	8 weeks	12 weeks
0.0%, 0.0%	4.643[a]	4.286[a]	4.321	4.143
2.0%, 0.0%	4.607[a]	4.355[a]	4.607[a]	4.857
0.0%, 0.5%	4.536[a]	4.072	4.072	4.465
2.0%, 0.5%	4.893	4.464	4.786[a]	5.394

[a]Means in a column followed by the same letter are not significantly different ($P<0.05$).

Table 5. Mean flavor values as affected by NaCl and HMP treatments and by freezer storage time. Higher values indicate better flavor.

Treatment NaCl HMP	Freezer storage 0 weeks	4 weeks	8 weeks	12 weeks
0.0%, 0.0%	5.321[a]	4.643[a]	4.179[a]	4.393
2.0%, 0.0%	5.357[a]	4.857[a]	4.965	4.822[a]
0.0%, 0.5%	4.857	4.322	4.179[a]	4.857[a]
2.0%, 0.5%	5.536	4.749[a]	5.036	5.821

[a]Values in a column followed by the same letter are not significantly different ($P<0.05$).

CONCLUSIONS

The data from the triangle differentiation test were consistent throughout the study, indicating that the panelists could detect a significant difference between products. The addition of NaCl and HMP to restructured beef chuck steaks increased sensory panel acceptability. Shear force increased linearly with time, with the exception of T4. Appearance and flavor scores generally decreased over storage time, but T4 showed an increased acceptability. It appeared that freezer storage, for up to 84 days, did not effect the sensory properties of T4.

This study suggests that the meat industry may benefit from adding NaCl and phosphate to steaks restructured from the chuck portion of the beef carcass.

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