Injection of Sodium Chloride, Sodium Tripolyphosphate, and Sodium Lactate Improves Warner-Bratzler Shear and Sensory Characteristics of Pre-Cooked Inside Round Roasts

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Story in Brief

Paired inside rounds (n=30 pairs) were obtained from randomly selected USDA Select quality grade carcasses to examine the effects of injecting a solution of sodium lactate, sodium tripolyphosphate, and sodium chloride on Warner-Bratzler shear force, cooking loss, lipid oxidation, and sensory characteristics of pre-cooked beef. Injected treatments were more tender than control products, as measured by Warner-Bratzler shear force (WBS) and consumer sensory panel ratings. Injected treatments had lower cooking and re-heating loss percentages when compared to control samples. Lipid oxidation in injected treated samples was significantly reduced as compared to control meat samples. Results of lipid oxidation also revealed that 14-d samples were less oxidized than 0-d samples. Results of this experiment have shown that injection of this solution decreased cooking loss, enhanced sensory panel characteristics, and improved WBS values.

Key Words: Beef, Injection, Consumer panel, Tenderness, Cooking-loss

Introduction

The trend of the U.S. consumers from traditional ways of preparing meals to methods that decrease cook time is especially important to the beef industry because there are many beef cuts that require time and cooking knowledge to maximize palatability. The beef industry's inability to adapt to these changes could result in further loss of market share by the beef industry. The beef industry must find more attractive ways to merchandise its products in order to maintain and improve its market share (Hollingsworth, 1997).

One quality that beef consumers prefer is beef tenderness. Boleman et al. (1997) demonstrated that consumers are willing to pay a premium for beef that is known to be tender, when compared to a less tender counterpart. Colorado State University (Vote et al., 2000)showed that injecting a solution containing sodium lactate, sodium tripolyphosphate, sodium chloride, and water into meat, and significantly improved tenderness and juiciness when compared to non-injected controls. This procedure is referred to as "enhancement." The objective of this study was to examine the influence of the enhancement procedure on one of the toughest beef muscles, the inside round.

Materials and Methods

Sample Preparation. Paired beef inside rounds (n=30 pairs) were individually identified and obtained from randomly selected, USDA Select quality grade carcasses, at a commercial beef processing facility. Meat samples were stored at 4°C $\pm$1° C for a total of 14 d. Following postmortem aging, paired samples were removed from the packaging material, trimmed of

external fat, and the gracilis muscle was removed. Paired muscle samples were cut in half and assigned to one of four injection treatment groups (0%, 5%, 7%, and 9% target injection levels). Samples were injected using a multi-needle injector, and all injection treatments were formulated to contain on a weight to volume basis 0.25% sodium tripolyphosphate, 0.35% sodium chloride, and 2% sodium lactate in the final product. Following injection, samples were stored for 24 h at 4°C $\pm$ 1°C to allow for equilibration. Samples were weighed and placed in vacuum package bags. Oxygen transmission rate of the cook-in bags was 20cc/m^2/24 h at 1 atmosphere (23°C at 0% relative humidity). The samples were then cooked to a primary internal temperature of 68°C $\pm$ 3°C in an Alkar® smokehouse. Cooked samples were then chilled at 4°C $\pm$ 1°C, for 16 h to simulate normal retail conditions. Meat samples were removed from bags and weighed for cooking loss before fabrication into 2.54 cm steaks (n=4). Steaks were then re-packaged in cook-in bags. The steaks were used for sensory, Warner-Bratzler shear (WBS), and Thiobarbituric acid (TBA) analysis. After seven days of storage at 4°C $\pm$ 1°C, WBS samples were removed and individually heated in a microwave oven (1500 W) to an internal temperature of 44°C $\pm$ 5°C (approximately 190 s). An automatic food rotator was placed in the center of the microwave to ensure uniform heating of all steaks. Samples were then allowed to cool for 30 min at room temperature (approximately 23°C). Six cores per steak (1.27 cm in diameter), taken parallel to muscle fiber orientation, were sheared across the muscle fiber using a Universal Instron Testing Machine with a Warner-Bratzler shear attachment. Individual shear force values for each steak were averaged, and the mean was used in statistical analysis.

Sensory Evaluation. Samples where stored in the absence of light at 4°C $\pm$ 1°C, and then the samples for sensory evaluation were randomly assigned to a storage period (21, 28, and 35 d), with an equal representation of all treatments present for all storage days. Consumer panelists, (n=99 people) evaluated samples for the sensory characteristics of aroma, overall appearance, flavor, and overall acceptability using a 7-point scale (1 = dislike very much and 7 = like very much). Juiciness and overall tenderness were also evaluated using an 8-point scale (1 = extremely tough, dry; and 8 = extremely juicy, tender). Steaks used for sensory evaluation were reheated using the same method to determine shear force. After reaching an internal temperature of 44°C $\pm$ 5°C, steaks were placed into aluminum foil pouches until evaluation. A minimum of eight panelists was present for each evaluation session.

Thiobarbituric Acid Analysis. Samples utilized for TBA determinations were stored in the absence of light at 4°C $\pm$ 1°C. The analysis was performed on samples at 0 and 14 d after cooking. After 14 d TBA samples were frozen at –17°C ± 2°C until analysis was performed. Thiobarbituric acid (TBA) analysis was performed using the procedure outlined by Witte et al. (1970) with the following modifications. A 10-g sample was used in the extraction step, and 35 ml of the slurry was centrifuged at 2500 rpm for 25 min prior to filtration. Results were reported as Thiobarbituric acid reactive substances (TBARS), which represented mg malondialdehyde (MDA) equivalents/kg of meat.

Statistical Analysis. Data were analyzed using the mixed-model procedures (SAS, 1998). The statistical model included fixed effects for treatment (0%, 5%, 7%, 9%), day (0, 14 for TBA, and 21, 28, 35 for sensory), and two-way interactions among fixed effects. The model also included ID as a random effect. Means were separated by Least Significant Difference option of SAS. Treatment differences were tested to a predetermined significance level of $P<.05$.

Results and Discussion

Shear Force Analysis. Analysis revealed no significance differences between treatment groups (data not shown), therefore the injection levels of 5%, 7%, and 9% were combined (pooled) into a common group referred to as injected. This agrees with Vote et al. (2000), in that injected treatments were significantly different from the controls with no significant differences among injected treatments. Least squares means comparing untreated controls and pooled injection treatments for WBS values and sensory characteristics describing tenderness difference are presented in Table 1. These results would suggest that injection of beef with sodium tripolyphosphate, sodium lactate, and sodium chloride reduced beef toughness by approximately one kg of force.

Table 1. Least squares means and standard errors for WBS force and sensory panel rating of untreated control and injected top round steaks.

Trait[a]	Control	Injected
Aroma	4.24[b] (.09)	4.57[c] (.05)
Appearance	3.94[b] (.13)	4.48[c] (.08)
Juiciness	2.67[b] (.16)	4.65[c] (.09)
Flavor	2.82[b] (.13)	4.49[c] (.08)
Tenderness	3.24[b] (.21)	4.96[c] (.15)
Acceptability	2.75[b] (.19)	4.46[c] (.14)
WBS, kg	4.58[c] (.09)	3.64[b] (.05)

[a] Aroma, appearance, flavor, and acceptability were all evaluated using a seven point rating scale (7= like very much, 1= dislike very much). Juiciness and tenderness were scored using an eight-point scale (8= extremely juicy or tender, 1= extremely dry or tough).

Sensory Panel Ratings. Mean sensory panel ratings and shear force values of untreated controls are presented in Table 1. Significant differences ($P<.05$) were found between untreated steaks and all treatment steaks regardless of injection for all sensory characteristics. The only exception to this was the 5% injection treatment, which was not significantly different ($P=.14$) from the control group when comparing visual appearance rating across all sensory days.

Storage time affected flavor, tenderness, and acceptability. It was found flavor following 28 d of storage to be more acceptable when compared to the 35 d samples. However, no flavor differences between 21 and 28 d samples, or 21 and 35 d were detected. For tenderness, panelist ratings were higher ($P<.05$) at 21 and 28 d when compared to 35 d samples. Lastly, panelists found acceptability to be significantly higher at 28 d when compared to 35 d steaks. There was a treatment by day interaction for sensory juiciness score. Within the 5% treatment group, a significant difference was found among the 21and 35, 28 and 35 d steaks. The 5% treatment group at 35 d was significantly different ($P<.05$) from both the 7% and 9% treatments for all sensory days. Sensory panel rating also showed that addition of sodium lactate improved juiciness when compared to controls at d 0 of storage as well as having a stabilizing effect throughout the storage periods.

Cooking Loss. When measuring cooking loss following the primary cooking stage of the roasts, a significant difference ($P<.05$) was found between all treatment groups when compared to controls, as presented in Table 2. Papadopoulos et al. (1991) found that with increasing levels of

sodium lactate, cooking loss decreased. In addition they also looked at the effect on cooking loss when adding sodium tripolyphosphate alone, and by adding sodium chloride alone. Decreased cooking losses were found for each treatment when compared to controls.

Table 2. Effect of injection treatment and storage on TBA values (mg malondialdehyde/kg), cooking loss (%)

	Means	
Item	**Cooking Loss[1]**	**TBA[2]**
Treatment		
0%	25.58[a]	1.24[a]
5%	17.69[b]	.649[b]
7%	17.54[b]	.733[b]
9%	18.58[b]	.743[b]
SEM	0.549	.122
Storage, d		
0	---	1.26[a]
14	---	.415[b]

[abcdef] Within a column and main effect, means without a common superscript letter differ (P<.05).

[1] Cooking loss was taken after initial cooking of the roast.

[2] TBARS measurement for treatments where pooled and analyzed for day 0 and 14.

A treatment by day effect was observed for loss at re-heating roast beef samples as shown in Table 3. Significant differences were observed in the 5% treatment group across all storage d when compared to all controls at all storage days with the one exception at 35 d. When comparing the 7% injection group treatment with non-injected controls for all storage periods, only three treatment-by-day interactions were not found to be significant. Lastly, comparing 9% injected products with controls showed three interactions to be not significant. These differences were observed when comparing storage d 21 for the 9% injected treatment, and storage d 21, 28, and 35 for controls. Among the three significantly different interactions between injected treatments, no real pattern was established. Therefore, a conclusion regarding the effect of varying levels of injected solution on cooking loss cannot be made.

Table 3. Effects of injection treatments on Least Square Means values for reheating loss percentages of microwave reheated inside round steaks

	Injection Treatments			
Item	Control	5%	7%	9%
Reheating Cooking Loss %				
Day 21	15.85[a]	12.32[ef]	11.93[f]	13.37[cde]
Day 28	15.09[ab]	12.66[def]	13.08[cdef]	13.18[cde]
Day 35	14.46[bc]	13.14[cdef]	14.11[bcd]	13.15[cdef]

[abcdef] Within a column and main effect, means without a common superscript letter differ (P<.05).

Thiobarbituric Acid. Lipid oxidation, as indicated by TBARS was found to be lower ($P<.05$) in injected steaks when compared to controls. Likewise, when compared over storage days, 14-d sample values were significantly lower ($P<.05$) than 0-d values (Table 2). Paterson et al. (1988) measured TBA values and found beef roasts injected with 0.475% sodium tripolyphosphate and 1% sodium chloride when compared to control values for treated samples were significantly reduced. While values did increase during storage, they were still much lower than controls (Paterson et al. 1998). These results were attributed to the antioxidative properties of sodium tripolyphosphate.

Implications

The results of this study indicate that injection of sodium tripolyphosphate, sodium chloride, and sodium lactate in select beef inside rounds is a potential way of increasing tenderness, enhancing sensory characteristics, and decreasing cooking loss and lipid oxidation.

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