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EFFECT OF FREEZING METHOD AND CALCIUM CHLORIDE INJECTION ON BEEF LONGISSIMUS MUSCLE TENDERNESS

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Story in Brief

This study evaluated the effects of freezing and crust freezing in conjunction with calcium chloride injection and postmortem aging on beef longissimus tenderness. Striploins were obtained from both carcass sides and fabricated into 1-in steaks. From the left striploin, four steaks were used as a control and separated into 3, 7, 14 or 21 d aging treatments. The remaining samples were used for freeze and crust freeze treatments and aged for 7, 14 or 21 d. One steak from the right striploin was used as a control for sensory analysis. The remaining portion of the right striploin was injected with a 20% calcium chloride solution (injected as 5% of subprimal weight) and allowed 4 h to equilibrate. The injected samples were further fabricated and allocated to three treatment groups: control, freeze and crust freeze and aged 7 d. Treatments were analyzed for Warner-Bratzler shear (WBS) force, calpastatin activity, sensory evaluation and cooking loss. Steaks from crust freeze groups had higher WBS force values relative to other treatments. Control steaks had lower WBS force values than freeze treatments at 14 and 21 d postmortem. Calcium chloride injection significantly reduced WBS force values in both control and crust freeze treatments relative to their non-injected counterparts. Calpastatin activity was reduced in all calcium chloride injected treatments. Sensory panelists classified approximately 20% more steaks as being tender due to $CaCl_2$ injection. Therefore, crust freezing should be eliminated from daily processing due to its detrimental effect on tenderness and cooking loss when not used in conjunction with calcium chloride injection.

Key Words: Tenderness, Calcium Chloride, Freezing

Introduction

The 1995 National Beef Quality Audit (NBQA) revealed that consumers have a major concern for lack of consistency and toughness from beef products purchased today (Boleman, 1988). In 1976, beef consumption per capita peaked at 97 lb on a retail weight basis, and since then has been in a downward trend to where in 1996 consumption resides at 68 lb per capita. The 1995 NBQA also revealed that $137.82 was lost per steer or heifer due to quality defects, and of that loss approximately one-third was attributed to taste and tenderness. Crouse and Koohmaraie (1990) reported freezing prior to postmortem aging enhanced beef steak tenderness due to increased proteolysis. Numerous researchers have reported dramatic improvements in tenderness as a result of calcium chloride injection. Therefore, this study

was conducted to examine the effects of freezing and crust freezing in conjunction with calcium chloride injection and postmortem aging on beef muscle tenderness.

Materials and Methods

Steers (n=75) of similar age and frame size, while varying in breed type from 0 to 50% *Bos indicus*, were fed at a commercial feedyard in the Texas Panhandle and harvested according to current commercial industry standards. At 24 h postmortem, a loin sample was obtained for calpastatin activity, and after the 48 h chilling period, complete grade was collected on all carcasses. During fabrication, both striploins were obtained and transported to the Oklahoma State University Food and Agriculture Products Research and Technology Center.

The left striploin served as a non-injected control (CON) and was fabricated into 10, 1-in steaks. Four steaks used as a CON, were vacuum packaged, placed in a 34^{o}F cooler and left to age for 3, 7, 14, or 21 d. Three additional steaks were used for the 40-d freeze (FRZ) treatment, placed in a -34.5^{o}F blast freezer for 40 d, then aged for 7, 14, or 21 d. The remaining portion of the left striploin was placed in a −23.5 ^{o}F freezer for 2.5 h for the crust freeze (CF) treatment, which involves freezing the outer 2 in of the meat sample, followed by a tempering stage to reach a final temperature of 28^{o}F. The sample was then fabricated into three 1-in steaks and aged for 7, 14 or 21 d in a 34^{o}F cooler. The right striploin was fabricated into five 1-in steaks. One steak was removed for sensory analysis and the remaining portion of the striploin was injected with a 20% $CaCl_2$ solution (injected as 5% of the subprimal weight) using a Formaco Multi-needle injector and allowed to equilibrate for 4 h. Another steak was then removed to complete the sensory evaluation. The remaining steaks were used for the calcium CON, FRZ and CF treatments. All $CaCl_2$-injected treatments were treated in the same manner as the aforementioned non-injected treatments except for being aged 7 d. Upon completion of the aging periods all steaks were stored in a -34.5^{o}F blast freezer to await cooking.

Calpastatin Activity. A loin muscle sample was taken 24 h postmortem and also at the completion of CF and FRZ periods. All samples were assayed by the same procedure as described by Shackelford et al. (1994).

Warner-Bratzler Shear Force and Cooking Loss Determination. Steaks were thawed at 39^{o}F for 24 h and the precooked weight was recorded. Steaks were broiled on a Lincoln Impinger oven set at 348^{o}F for 16.5 min to reach an internal temperature of 158^{o}F. Temperatures were monitored using an Omega 202 Temperature Logger. Steaks were allowed to equilibrate at room temperature and cooked weight was recorded. Cooking loss was expressed as a percentage by subtracting cooked weight from precooked weight then dividing by precooked weight. Six to eight cores (½-in

diameter) were removed parallel to the muscle fiber orientation. Cores were sheared using a Universal Instron testing device with a Warner-Bratzler shearing attachment.

Sensory Evaluation. One $CaCl_2$-injected and one CON steak were obtained from each carcass for sensory panel analysis. Steaks were cooked in the manner described previously. A seven to ten member trained panel rated samples according to the procedures outlined by AMSA (1995). Steaks were evaluated for overall tenderness, juiciness, flavor intensity and connective tissue amount using an eight-point scale (8 = extremely tender, juicy, intense, and no connective tissue; 1 = extremely tough, dry, bland and abundant connective tissue). Cooked beef fat flavor was scored on a three-point scale (2 = very strong; 0 = none detected) and off-flavor on a four-point scale (4 = none; 1 = intense).

Statistical Analysis. Data were analyzed by analysis of variance using a split block procedure (SAS, 1994). All means were separated using Fisher□s LSD.

Results and Discussion

Effect of Storage Treatment on Longissimus Muscle Tenderness. Warner-Bratzler shear (WBS) values were influenced by a storage treatment x postmortem aging time interaction, in that CF and CON steaks aged in a similar pattern with a decline in WBS throughout the 21-d aging period (Table 1). However, FRZ steaks did not respond to postmortem aging. FRZ steaks had negative effect on tenderness when compared with CON steaks ($P>.05$). Also, CF showed a negative effect on WBS values, increasing WBS approximately 2.2 lb at 7 d. CF resulted in pronounced increases in WBS at all aging periods.

Effect of Storage Treatment and $CaCl_2$ Injection on Cooking Loss. Cooking loss was affected by a storage treatment by postmortem aging time interaction in that steaks from CF and FRZ displayed higher ($P<.05$) cooking losses than all corresponding CON treatments (Table 1). Additionally, $CaCl_2$-injected steaks from CF and FRZ also had greater ($P<.05$) cooking losses relative to $CaCl_2$-injected CON steaks (Table 2).

Effect of Storage Treatment and $CaCl_2$ Injection on Longissimus Muscle Tenderness. There were no improvements in tenderness associated with FRZ with or without $CaCl_2$ injection (Table 2). $CaCl_2$-injected steaks were more tender than non-injected CON steaks. WBS was significantly reduced in the $CaCl_2$-injected CF treatments if compared with non-injected CF treatments. However, both CF treatments were still tougher than any other treatment.

Effect of $CaCl_2$ Injection and Storage Treatment on Calpastatin Activity.

$CaCl_2$ injection decreased calpastatin activity in all corresponding treatments (Table 2). Compared with CON steaks, all storage and $CaCl_2$-injected treatments had reduced (P<.05) calpastatin activity. Calpastatin activity was higher in FRZ and CF steaks than in the other treatments. Higher calpastatin activity in the CF treatments are in agreement with WBS values.

Effect of $CaCl_2$ Injection on Sensory Evaluation. $CaCl_2$-injected steaks tended to be rated tender more frequently when compared with CON steaks which were characterized as slightly tough (Table 3). Additionally, sensory panelists perceived 20% more $CaCl_2$-injected steaks as being tender when compared with non-injected CON steaks. Results from this study showed no differences in juiciness, cooked beef fat flavor and connective tissue. However, $CaCl_2$ did result in increased flavor intensity and off-flavors (P<.05) when compared with non-injected CON steaks.

Results from this study suggest that $CaCl_2$ injection improves WBS values and sensory tenderness ratings. Additionally, CF of beef should be eliminated from daily processing due to its detrimental effect on tenderness and cooking loss properties. It appears that extensive FRZ should be used for preservation purposes and not as a technique to improve overall palatability.

Literature Cited

AMSA. 1995. AMSA and National Livestock and Meat Board, Chicago, IL.

Boleman, S.L. et al. 1988. J. Anim. Sci. 76:96.

Crouse, J.D. and Koohmaraie, M. 1990. J. Food. Sci. 55:573.

SAS. 1994. SAS/STAT User□s Guide (Version 6, 4th Ed.). SAS Inst. Inc., Cary, NC.

Shackelford, S.D. et al. 1994. J. Anim. Sci. 72:857.

Table 1. Effect of storage on WBS and cooking loss of steer longissimus muscle at 7, 14 or 21 d postmortem aging.

Item	WBS, lb	Cooking loss, %
Treatment[a]	N=225	N=225
Crust freeze	11.29	26.83
Freeze	10.05	25.95
Control	9.33	23.74

Days Postmortem		
7	11.31	25.39
14	10.05	25.64
21	9.37	25.50
SE[b]	1.83	2.34
Treatment x day postmortem aging	N=75	N=75
Probability level	<.01	<.01
Control / 7d	10.82[d]	23.96[g]
Control / 14 d	9.09[g]	24.40[g]
Control / 21 d	8.21[h]	22.85[h]
Crust freeze / 7 d	12.85[c]	26.78[e]
Crust freeze / 14 d	10.71[de]	25.72[f]
Crust freeze / 21 d	10.27[de]	28.01[d]
Freeze / 7 d	10.23[ef]	25.43[f]
Freeze / 14 d	10.32[de]	26.80[e]
Freeze / 21 d	9.66[f]	25.64[f]

[a]See Materials and Methods for details of treatment.

[b]Standard errors for the means can be calculated using the following equation: SE=RMSE/√ n.

[c,d,e,f,g,h]Means within a column lacking a common superscript differ (P<.05).

Table 2. Effect of storage treatment and $CaCl_2$ injection on calpastatin activity, WBS and cooking loss.

Treatment	Calpastatin activity, units of muscle	WBS[1], lb	Cooking loss, %
Control[2]	2.87[a]	10.82[c]	23.96[b]
$CaCl_2$[3]	1.38[c]	10.08[b]	24.45[b]
Freeze[3]	1.84[b]	10.23[bc]	26.32[c]
$CaCl_2$/Freeze[3]	1.02[d]	10.27[bc]	26.82[cd]
Crust freeze[4]	1.92[b]	12.85[e]	26.78[cd]
$CaCl_2$/Crust freeze[4]	1.22[cd]	12.03[d]	27.62[d]
SE[f]	.61	2.07	3.62

[a]See Materials and Methods for details of treatment.

[b,c,d,e]Means within a column lacking a common superscript differ (P<.05).

[f]Standard errors for means can be calculated using the following equation: SE=RMSE/√ n.

[1]WBS and cooking loss were taken after 7 d postmortem.

[2]Calpastatin activity at 24 h postmortem.

[3]Calpastatin activity after 3 d aging and completion of storage treatment.

[4]Calpastatin activity after 4 d aging and completion of storage treatment.

Table 3. Effect of $CaCl_2$ injection on sensory panel ratings of longissimus muscle following 7 d postmortem aging.

Item	Juciness[a]	Cooked beef fat flavor[b]	Off flavor[c]	CT[d]	Flavor intensity[e]	Tenderness[f]	Tender steaks, %
Treatment							
Control	4.80	.45	3.95[h]	5.25	5.03[h]	4.96	44
$CaCl_2$	4.77	.45	3.87[I]	5.35	5.14[I]	5.10	64
P-value	.68	.91	<.01	.17	.02	.13	
SE[g]	.43	.22	.14	.46	.28	.59	

[a]8 = extremely juicy, 1 = extremely dry.

[b]2 = very strong, 0 = none detectable.

[c]4 = none, 1 = intense.

[d]Connective tissue, 8 = none, 1 = abundant.

[e]8=extremely intense, 1 = extremely bland.

[f]8 = extremely tender, 1 = extremely tough.

[g]Standard errors can be calculated using the following equation: SE = RMSE/√ n.

[h,i]Means within a column lacking a common superscript differ (P<.05).

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