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Abstract

A study was conducted to determine if excised, cold-shortened muscle improves in tenderness with refrigerated aging. Changes in muscle tenderness due to cooking rates were also evaluated. Beef ribeye and shoulder clod muscles from the left side of 12 carcasses were removed 45 min postmortem and placed in an ice bath to induce cold shortening. Corresponding muscles from the right side were chilled conventionally on the intact side. One-inch steaks from these muscles were either frozen at 24 hours or aged for 14 days at 40ºF before being cooked and analyzed. Steaks were analyzed raw, or cooked to 160ºF internally in a oven at 200 (SLOW) or 500°F (FAST). Sarcomere length (degree of contraction), tenderness, and the extent of degradation of structural proteins were measured. Rapid chilling caused severe muscle contraction, which had a dramatic toughening effect. At 24 hours, the cold-shortened muscle showed less protein degradation than conventionally chilled muscle. After aging 14 days, tenderness had improved and protein degradation had occurred in both cold-shortened and conventional muscles, but degradation was still less in cold-shortened muscles. The improvement in tenderness and the increase in protein degradation from 1 to 14 days were equal between cold-shortened and conventional chilling treatments but the cold-shortened muscles remained tougher. FAST cooking resulted in greater cooking losses and greater sarcomere shortening than SLOW cooking. Cooking rate did not affect the tenderness of ribeye steaks, but SLOW cooking improved the tenderness of shoulder clod steaks that are higher in connective tissue. Extreme chilling conditions, which induce cold shortening, may reduce protein degradation beyond the effect of shortening. Although aging improved the tenderness of cold-shortened muscles, they remained tougher than their conventionally chilled counterparts.

Keywords

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EFFECTS OF COLD SHORTENING AND COOKING RATE ON BEEF TENDERNESS

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Summary

A study was conducted to determine if excised, cold-shortened muscle improves in tenderness with refrigerated aging. Changes in muscle tenderness due to cooking rates were also evaluated. Beef ribeye and shoulder clod muscles from the left side of 12 carcasses were removed 45 min postmortem and placed in an ice bath to induce cold shortening. Corresponding muscles from the right side were chilled conventionally on the intact side. One-inch steaks from these muscles were either frozen at 24 hours or aged for 14 days at 40ºF before being cooked and analyzed. Steaks were analyzed raw, or cooked to 160ºF internally in a oven at 200 (SLOW) or 500°F (FAST). Sarcomere length (degree of contraction), tenderness, and the extent of degradation of structural proteins were measured. Rapid chilling caused severe muscle contraction, which had a dramatic toughening effect. At 24 hours, the cold-shortened muscle showed less protein degradation than conventionally chilled muscle. After aging 14 days, tenderness had improved and protein degradation had occurred in both cold-shortened and conventional muscles, but degradation was still less in cold-shortened muscles. The improvement in tenderness and the increase in protein degradation from 1 to 14 days were equal between cold-shortened and conventional chilling treatments but the cold-shortened muscles remained tougher. FAST cooking resulted in greater cooking losses and greater sarcomere shortening than SLOW cooking. Cooking rate did not affect the tenderness of ribeye steaks, but SLOW cooking improved the tenderness of shoulder clod steaks that are higher in connective tissue. Extreme chilling conditions, which induce cold shortening, may reduce protein degradation beyond the effect of shortening. Although aging improved the tenderness of cold-shortened muscles, they remained tougher than their conventionally chilled counterparts.

(Key Words: Beef Tenderness, Cooking Rate, Cold Shortening.)

Introduction

Degree of contraction affects the tenderness of muscle. Without skeletal restraint, muscles exposed to cold will enter rigor in a contracted state, a condition called cold shortening. Previous reports as to whether or not aging would improve tenderness of cold-shortened muscle are mixed. Some researchers have suggested that the greater overlapping of proteins in contracted muscle blocks access to proteins by the calpain enzyme system. Some earlier research has indicated that protein in cold-shortened muscle degrades at a rate similar to normal muscle. Therefore, we evaluated the effect of aging on tenderness and extent of protein degradation in normal and cold-shortened muscle. In addition, the beef industry needs to more effectively utilize muscles from the round and chuck. One muscle with potential for greater use is the *triceps brachii*, commonly sold as part

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of the shoulder clod. Because of the demand for more pre-cooked products, we were interested in the effects of cooking rates on ribeye and shoulder clod muscles as well as the heating rate effect on tenderness of cold-shortened muscle.

Experimental Procedures

Twelve Charolais-Angus crossbred heifers from a local feeder were harvested in the Kansas State University Meat Laboratory. Approximately 45 min after death, *longissimus* (ribeye) and *triceps brachii* (shoulder clod) muscles were removed from the left side and placed in an ice bath to cause cold shortening. The right side was chilled intact and corresponding muscles were removed after 24 hours (conventional chill).

All muscles were cut into one-inch thick steaks. Steaks were either frozen at 1 day or aged 14 days at 40°F. Some steaks were analyzed raw, others after cooking to 160º F internally in a gas-fired, forced-air convection oven set at either 200 or 500° F. The sarcomere length (extent of contraction) and the extent of protein degradation were measured on all steaks. For cooked steaks, cooking losses were recorded. Steaks were chilled for 24 hours before six, half-inch cores were removed and tenderness was measured using Warner-Bratzler shear force. Analysis of variance was used to identify differences between treatments.

Results and Discussion

Our cold shortening treatment produced severe contraction; the shoulder clod and ribeye muscles shortened 34 and 29%, respectively (Table 1). Rapid chilling and the resulting cold shortening decreased desmin degradation and increased Warner-Bratzler shear force, but did not affect cooking losses (Table 2). A number of structural proteins, including desmin, are degraded by the calpain enzyme during aging. Desmin degradation is thought to play a role in tenderization and is also believed to indicate the extent of degradation of other proteins. Cold shortening reduced desmin degradation by 30.5% vs. 40.9% for conventional muscles. Desmin degradation increased in all steaks, conventioal or cold-shortened, between day 1 and day 14 of aging (Table 3). Chilling and aging treatments did not interact, indicating that the change in desmin degradation between day 1 and day 14 was not affected by chilling treatment. Thus, the difference in protein degradation between chilling treatments occurred during the first 24 hours postmortem.

Table 1. Average Sarcomere Length of Beef Ribeye and Shoulder Clod Steaks

Muscle	Treatment	Sarcomere Length (μm)
Ribeye	Conventional	1.8^{x}
Ribeye	Cold-shortened	1.3^{z}
Shoulder clod	Conventional	2.1^{w}
Shoulder clod	Cold-shortened	1.4^{y}
SEM		0.03
P>F		<0.01

^{w,x,y,z}LS means lacking a common superscript letter differ (P<0.05).

Table 2. Desmin Degradation, Warner-Bratzler Shear Force, and Cooking Loss of Beef Ribeye and Shoulder Clod Steaks

Treatment	Desmin Degraded[a] (%)	WBSF[b] (kg)	Cooking Loss (%)
Chilling Effect			
Conventional	40.9[z]	10.6y	26.0
Cold-shortened	30.5[x]	22.1[z]	25.2
SEM	2.6	0.62	0.55
P>F	<0.01	<0.01	0.23
Aging Effect			
1 day	--	17.2[z]	24.9
14 day	--	15.0[y]	26.2
SEM	--	0.55	0.55
P>F	--	<.01	0.06

[a]Determined by comparing samples to an at death standard.
[b]Warner-Bratzler shear force.
[y,z]LS means within a column and main effect lacking a common superscript letter differ (P<0.05).

Cold-shortened muscles were much tougher than muscles chilled on the carcass (Table 2). Warner-Bratzler shear force of both cold-shortened and conventionally chilled muscles decreased with aging (Table 3). The lack of an interaction between chilling treatment and aging treatment for shear force indicated that the increase in tenderness from 1 to 14 days was equal for both chilling rates. However, aging did not diminish the toughening effect of cold shortening. Cooking losses were not affected by chilling rate, but aging tended to increase cooking losses (Table 2).

Cooking reduced sarcomere lengths of conventional by chilled samples (Table 4), with FAST cooked steaks having the greatest sarcomeres shortening. Cooking also shortened sarcomeres of the cold-shortened muscle, but there was no difference due to cooking rate. Cooking rate had no effect on the extent of protein (desonin degradation (Table 5), but raw ribeye steaks underwent more degradation than FAST cooked steaks.

FAST cooking caused greater cooking losses than did SLOW cooking (Table 5). This difference was much greater in the ribeye than in shoulder clod steaks. However, shoulder clod steaks had greater cooking losses at both cooking rates than the ribeye steaks. Cooking rate did not affect WBSF of the ribeye steaks. When the shoulder clod steaks were cooked FAST, they were equal in Warner-Bratzler shear force to the ribeye steaks, but when cooked SLOW, were more tender than ribeye steaks. Shoulder clod has more connective tissue and SLOW cooking likely minimized the negative effects of heating on the connective tissue that occurs with FAST cooking.

Table 3. Desmin Degradation and Warner-Bratzler Shear Force Values for Beef Ribeye and Shoulder Clod Muscles

Chilling Treatment	Aging (days)	Desmin Degraded[a] (%)	WBSF[b] (kg)
Conventional	1	28.7	11.21
Conventional	14	53.1	9.7
Cold shortened	1	16.5	23.4
Cold shortened	14	44.6	20.3
SEM		2.97	0.71
P>F		0.35	0.13

[a]Determined by comparing samples to an at death standard.
[b]Warner-Bratzler shear force.

Table 4. Sarcomere Length of Beef Ribeye and Shoulder Clod Steaks as Affected by Chilling Rate and Cooking at Either 200 or 500°F

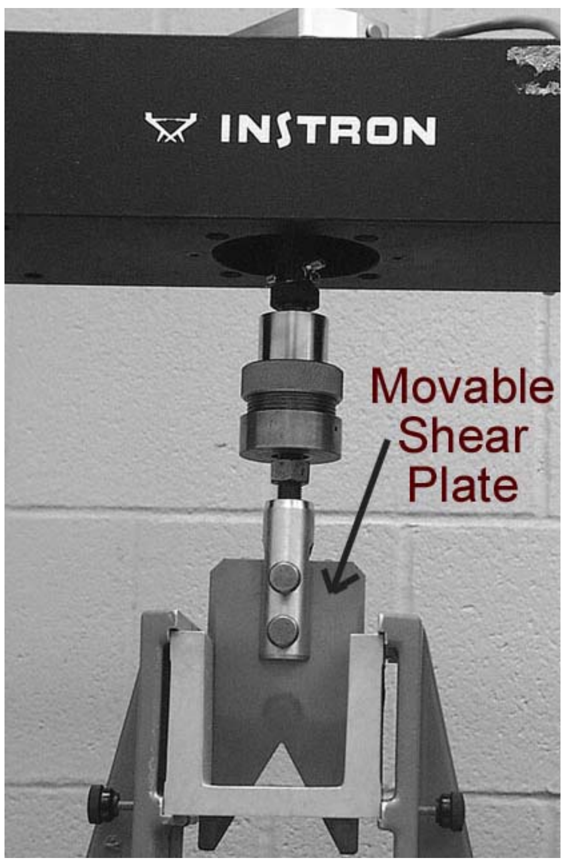
Shortening Treatment	Cooking Treatment	Sarcomere Length (µm)
Conventional	Raw	2.0[v]
Conventional	Fast[a]	1.8[x]
Conventional	Slow[b]	1.9[w]
Cold shortened	Raw	1.4[y]
Cold shortened	Fast[a]	1.3[z]
Cold shortened	Slow[b]	1.3[z]
SEM		0.02
P>F		<0.01

[a]Cooked in a forced-air convection oven with thermostat set at 500°F.
[b]Cooked in a forced-air convection oven with thermostat set at 200°F.
[v,w,x,y,z]LS means lacking a common superscript letters differ (P<0.05).

Table 5. Average Desmin Degradation, Warner-Bratzler Shear Force, and Cooking Losses of Beef Ribeye and Shoulder Clod Steaks Analyzed Raw or After Cooking at Either 200 or 500°F

Muscle	Cooking Treatment	Desmin Degraded[a] (%)	WBSF[b] (kg)	Cooking Loss (%)
Ribeye	Raw	40.1[y]	--	--
Ribeye	Fast[c]	31.8[z]	16.5[z]	27.1[y]
Ribeye	Slow[d]	34.3[yz]	16.8[z]	19.8[x]
Shoulder clod	Raw	33.2[yz]	--	--
Shoulder clod	Fast[c]	35.5[yz]	16.8[z]	29.7[z]
Shoulder clod	Slow[d]	40.3[y]	14.6[y]	25.7[y]
SEM		3.29	0.71	0.74
P>F		0.03	0.03	0.02

[a]Determined by comparing samples to an at death standard.
[b]Warner-Bratzler shear force.
[c]Cooked in a forced air convection oven with thermostat set at 500°F.
[d]Cooked in a forced air convection oven with thermostat set at 200°F.
[x,y,z]LS means within a column lacking a common superscript differ (P<0.05).



Warner-Bratzler Shear: A ½-inch core of meat is placed in the inverted "V" notch of the movable shear plate. The shear plate moves downward, and the Instron testing machine records the amount of force required to shear the core.