Mechanical Tenderization of Electically Stimulated Muscle

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Story in Brief

Cooking time, cooking loss, tenderness, and microbial counts of electrically stimulated blade tenderized muscles were examined. In most cases, no significant ($P<0.05$) differences were found in cooking time and and cooking loss among tenderized and non-tenderized muscles. However, the blade biceps femoris and semimembranous muscles were significantly ($P<0.05$) more tender than their control. Sanitizing the blading machine with an iodine based compound provided a 100 fold lower Aerobic Plate Count for the interior portion of the tenderized muscle as compared to the muscle surface count. In all instances Total Coliform and Total Enterobacteriaceae were $<1.0\times10^{1}$/g of meat.

Introduction

Tenderness is one of the most important quality attributes of meat. A number of procedures have been developed to improve meat tenderness. These procedures include, physical (carcass suspension, mechanical restraint of muscles), environmental (elevated pre rigor temperatures, post rigor aging), enzymatic (tropical plant or fungal enzymes) and electrical stimulation procedures which are all well established.

Recently studies have been conducted on blade tenderization of beef. Davis (1976) demonstrated that blading provided an increase in meat tenderness greater than that achieved by cooler aging. Blade tenderized muscles of beef were more tender than their control as determined by both a sensory panel and shear force values (Campbell, 1976; Glover, 1975), but these samples had a higher cooking loss. Both animal age and nutritional regimen may have an effect on the blade tenderization muscles (Campbell, 1976).

The purpose of this work was to evaluate the effect of blade tenderization of electrically stimulated muscles on the heat transfer, tenderness and microbial quality of the muscles.

Materials and Methods

Beef carcasses

Carcasses from commercial Angus and Hereford steers in the weight range of 271 to 302 Kg were used.

Electrical stimulation

The electrical stimulation (a square wave pulse of 300V, 400 cpm with a duration of 0.5 msec and a current of 1.6 to 1.8 amp) of beef sides started at 30 min post mortem and continued for 15, 5 and 2 min. Both sides, stimulated and non-stimulated, were held at 16 C during the stimulation and up to 1.5 hr post mortem.

Boning

The Semimebranosus (SM), Biceps Femoris (BF) and Longissimus Dorsi (LD), (from the end of the Ilium to the fifth thoracic vertebrae), muscles from the stimulated side were cut in half at the center of their long axis. This group was labeled "hot boned hot". The unstimulated side was stored at 1.1 C for 22-24 hr and served as a control (conventional boning). A portion of each hot boned muscle was chilled for 15 hr and labeled "hot boned chilled" then sampled for the various measurements.

Blade tenderization

One half of each muscle was blade tenderized twice (top and bottom) using a Hollymatic AMT 625A Blade Tenderizer (Hollymatic Corp., Park Forest, Illinois 60466). The other half of each muscle was kept as a control.

Heat Transfer studies

Steaks ((5.08 cm thick) were sampled from each half muscle at a location adjacent to the center of the whole muscle.

The steaks were heated using a Blodgett convection oven (the G.S. Blodgett Co., Inc., Burlington, Virginia) set at 163C to an internal temperature of 68.3 C. Cooking time and cooking loss were measured.

Shear force measurements

The cooked steaks were cooled for 40 min at room temperature (22-25 C) and chilled for 22-24 hr at 1.1 C to provide adequate firmness and uniform cores. Three cores were sampled from each steak using a mechanical borer. Each core was sheared three times by a Warner-Bratzler shear (J:Chatillon & Sons, New York, N.Y.).

Bacteriological Examinations

The exterior and interior portions of each uncooked BF muscle and the exterior portions of LD and SM muscles were aseptically sampled for bacteriological examinations by removing portions (50g) of the meat tissue. Each sample was blended for up to 2 min using 0.1 percent Peptone (Difco) water.

The Aerobic Plate Count was examined by spreading appropriate dilutions of examined samples on prepoured Plate Count Agar (Difco); plates

incubated at 22 C for 48 hr. Total Coliform and Total Enterobacteriaceae were examined using Violet Red Bile Agar and MacConkey Glucose Agar (BBL) respectively, incubated at 35 C for 24-48 hr.

The blade tenderizer was sampled by swabbing 10 cm^2 of the conveyer and two blades (surface area of 59.7cm^2) before, in between, and after the tenderization of the muscles. The tenderizing machine was sanitized using an iodine based sanitizer (Mikroklene DF, Klenzade Products).

Statistical analysis

The results were subjected to the analysis of variance and to the least significant range test (Steel, 1960).

Results and Discussion

Heat transfer

Cooking times of the three muscles used at the different stimulation periods are presented in Table 1. As Table 1 shows, there were no significant ($P<0.05$) differences among blade tenderized muscles and their control for the three stimulation periods. The cooking time of nontenderized "hot boned hot" BF muscle was significantly ($P<0.05$) shorter than the same muscle "hot boned chilled". The cooking time ranged between 71.8 and 126.0 min/kg meat. The cooking time of the "hot boned hot" muscles tends to shorten with the reduction of the stimulation time from 15 to 2 min. This trend and its significance will be further studied.

In all but a few cases the cooking losses of blade tenderized muscles (Table 2) were not significantly different ($P<0.05$) from that of their control. The cooking loss range did not vary among the different stimulation times and was between 22.2 and 36.6 percent.

The results of the heat transfer studies show that electrical stimulation of muscles may prevent larger cooking loss due to tenderization. These results are in contrast to other works (Campbell, 1976; Glover, 1975) which showed a larger cooking loss due to blade tenderization of non-electrically stimulated muscles.

Shear force

The shear force values of the tenderized "hot boned hot" and conventionally processed BF muscles (Table 3) at the three stimulation times were significantly ($P<0.05$) lower than the values of the non tenderized control. This was not case with the "hot boned chilled" treatment. No significant difference ($P<0.05$) was found between the tenderized LD muscle and its control in the different treatments and stimulation times. A significant difference ($P<0.05$) in shear force values was found only between the tenderized and the control of the "hot boned chilled" and conventionally processed SM muscle.

From these results one can see that blade tenderization of the outside and inside rounds improved their tenderness. Using 15 min stimulation periods

Table 1: Cooking time of some electrically stimulated blade tenderized muscles

Treatment	BF	LD	SM	BF	LD	SM	BF	LD	SM
	15*			5*			2*		
Hot Boned Hot* **	Cooking Time (min/kg)								
NT	71.8±32.7[ab]**	101.0±31.1	94.0±39.0	117.8±22.3	109.4±13.8	112.0±1.0	91.2−14.8	89.0±11.8	103±13.7
T	87.7±35.2	69.6±15.0[cd]	96.2±47.5	96.1±14.2	117.8±0.3	100.1±13.1	92.5±18.3	93.8±10.6	85.8±18.8
Hot Boned Chilled (1.1 C, 15 hr)									
NT	115.6±16.2[a]	117.4±13.6[c]	115.8±15.5	103.1±10.7	108.3±2.4	101.3±1.0	94.5±3.0	99.2±24.1	117.8±11.0
T	119.3±17.3[b]	98.5±19.7	104.3±8.1	100.5±3.1	102.2±8.1	97.3±1.0	88.3−28.9	105.5±26.5	99.4±21.8
Conventional Processing (Chilled 1.1 C, 24 hr)									
NT	99.1±9.1	99.6±13.0	100.8±8.0	100.0±10.3	126.0±30.1	111.3±7.5	98.2±11.3	90.5±4.6	103.0±13.4
T	100.4±28.1	111.5±12.0[d]	121.3±17.7	96.3±19.1	95.4±6.5	101.6±22.9	78.2±6.1	90.9±7.5	95.6±24.1

*Stimulation time (min).
**Numbers with the same superscript letter in each stimulation time are significantly different ($P<0.05$).
***NT=Non-Tenderized; T=Tenderized.

Table 2: Cooking loss of some electrically stimulated blade tenderized muscles

Treatment	BF	LD	SM	BF	LD	SM	BF	LD	SM
	15*			5*			2*		
Hot Boned Hot* **	(%)								
NT	23.5±3.3[a]**	25.8±0.9	27.2±2.2	26.0±4.6	24.4±0.8	28.2±0.4[a]	28.3±1.5	23.6±3.3	26.0±1.0
T	34.1±2.1[ab]	26.9±5.0[b]	30.6±6.7	32.5±2.0	26.9±0.3[c]	36.6±4.1[ac]	30.5±11.7	25.5±6.6	32.3±0.5
Hot Boned Chilled (1.1 C 15 hr)									
NT	28.0±1.3	24.4±0.7	27.7±2.8	22.2±6.3[bd]	22.3±3.9[e]	30.6±2.0[de]	25.1±3.6[a]	25.0±1.8	27.8±4.9
T	32.3±1.8[c]	26.6±3.5[c]	31.5±5.2	32.5±5.9[b]	26.0±1.3	32.2±2.8	34.3±3.2[a]	29.8±0.2	32.0±1.4
Conventional Processing (Chilled 1.1 C 24 hr)									
NT	26.9±3.0	23.8±0.8	27.8±3.6	32.0±2.8[f]	24.1±1.3[f]	31.5±2.0	27.5±0.8[b]	25.5±3.0	28.6±6.5
T	29.3±6.5	27.9±2.9	32.3±2.1	32.0±0.2	28.1±2.8	32.8±1.7	36.1±5.5[b]	28.5±2.1	32.3±3.8

*Stimulation time (min.)
**Numbers with the same superscript letter in each stimulation time are significantly different ($P<0.05$).
***NT=Non-Tenderized; T=Tenderized.

Table 3: Tenderness (shear force values) of some electrically stimulated blade tenderized muscles

Treatment	BF	LD	SM	BF	LD	SM	BF	LD	SM
	15*			5*			2*		
	(Kg/2.5 cm)								
Hot Boned Hot* **									
NT	13.2±4.4[a]**	11.7±4.9	12.4±2.9	19.0±6.6[ag]	9.9±1.5[g]	16.8±4.0[g]	18.5±4.4[ae]	16.3±2.4	16.5±5.8[h]
T	11.2±1.6[ad]	10.1±3.4[e]	13.0±2.8[de]	11.3±2.3[ah]	9.0±1.4[h]	16.0±3.8[h]	14.4±5.0[af]	15.5±3.2[g]	14.0±1.4[ij]
Hot Boned Chilled (1.1°C, 15 hr)									
NT	12.2±3.0	11.3±2.9	12.5±3.8[b]	12.2±2.1[bi]	7.9±1.5[i]	15.0±3.6[ei]	13.1±6.6[ek]	14.9±4.1	17.3±18[bk]
T	11.4±2.4[f]	10.1±2.7	9.4±2.5[bf]	9.9±2.5[b]	8.1±2.0[j]	11.7±2.6[ej]	14.7±5.5[L]	14.8±4.7[M]	9.9±1.9[bilm]
Conventional Processing (Chilled 1.1°C, 24 hr)									
NT	13.0±4.0[c]	12.2±2.6	13.5±2.4	13.1±2.1[c]	12.5±2.1	14.3±2.9[f]	15.9±4.6[c]	13.7±2.4	13.3±2.8[dh]
T	10.3±3.5[c]	10.8±2.5	11.8±3.5	9.4±2.4[c]	9.1±1.7	9.9±2.7[f]	9.9±3.2[cf]	12.1±1.9[g]	9.7±1.5[dj]

*Stimulation time (min.)

**Numbers with the same superscript letter in each stimulation time are significantly different ($P<0.05$).

***NT=Non-Tenderized; T=Tenderized.

Table 4: Aerobic plate count of some tenderized muscles

Treatment	E*	BF I**	LD*	SM*
		Count/g		
Hot Boned Hot* **				
NT	1.9×10^4	1.0×10^1	1.0×10^1	3.8×10^3
T	1.0×10^1	1.0×10^1	1.5×10^4	6.0×10^3
Hot Boned Chilled (1.1 C, 15 hr)				
NT	7.5×10^3	1.0×10^1	6.5×10^2	3.9×10^3
T	1.0×10^3	1.0×10^1	2.3×10^3	8.0×10^2
Conventionally Processed (Chilled 1.1 C, 24 hr)				
NT	1.0×10^3	1.0×10^1	1.0×10^1	6.0×10^2
T	3.8×10^3	1.0×10^1	1.1×10^3	2.0×10^3

*The exterior portion of the muscle.
**The interior portion of the muscle.
***NT=Non-Tenderized; T=Tenderized.

Table 5: Bacterial count of the tenderizing machine sanitized with an iodine compound***

Treatment	Conveyor (Count/cm²)	Blades (Count/2 Blades)**
	Count Range	
Sanitized before Tenderization*	2.1×10^3 ——— 1.0×10^1	1.0×10^3 ——— 1.0×10^2
After First Run of Muscles	2.0×10^3 ——— 1.0×10^1	5.0×10^1 ——— 1.0×10^1
After Second Run of Muscles	5×10^1 ——— 1.0×10^1	5.0×10^1 ——— 1.0×10^1

*The Iodine compound was left on the machine for two minutes before tenderization started.
**Blade dimensions: height 15.7 cm, length 1.5, width 0.4 cm (the surface area = 59.7 cm² or 9.2 in²)
***Mikroklene DF

resulted in no significant difference ($P<0.05$) between the tenderized BF and tenderized LD muscles in the three treatments. No significant difference ($P<0.05$) was found between the tenderized and non-tenderized LD muscle. One can say that blade tenderization may not improve the tenderness of this muscle.

Bacteriological examinations

The Aerobic Plate Count (Table 4) of the exterior portion of the muscles did not exceed 10^4/g. The Aerobic Plate Count of the exterior portion of the tenderized LD muscle was higher than its control by 10 to 10,000 fold. As shown Aerobic Plate Control of the interior portion of the tenderized BF muscle was not different than that of the non-tenderized control ($<1.0\times10^1$/g). These low counts were obtained due to a good sanitation program including the use of an FDA approved iodine based sanitizer. Table 5 shows that the bacterial contamination of the tenderizing machine was as low as $<1.0\times10^1$ to 2.1×10^3 per cm² conveyor or per 2 blades. Meat products with low bacteriological counts have a longer shelf life in refrigeration and the hazard from pathogenic microorganisms is reduced. The level of the Total Coliform and Total Enterobacteriaceae was in all instances $<1.0\times10^1$/g of meat.

Literature Cited

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The Storage Stability Of Electrically Stimulated Hot Boned Refrigerated Ground Beef

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Story in Brief

The storage stability of electrically stimulated ground beef was studied. An incubation temperature of 22 C was found accurate (correlation coefficient of 0.96) for the estimation of the psychrotrophic bacterial population of the product. Electrical stimulation prolonged the lag phase of the bacterial population but inhanced its growth rate (between the third and fifth days of storage). The shelf life of the electrically stimulated ground beef was extended by 3 days as compared to the nonstimulated control (4-5 vs 7-8 days respectively).

Introduction

The importance of ground beef is increasing every year in the U.S. The present consumption is 18.2 Kg/capita and it is believed that it will reach 22.7 Kg/capita a 25 percent increase (Meat Plant Magazine, 1977).

The bacteriological quality of raw ground beef is of concern to all segments of the industry. Reduced shelf life, discoloration of the product as a result of bacterial growth are often encountered. Goepfert (1976) reported an Aerobic Plate Count (APC) of 5×10^6/g in 34 percent of 955 samples of ground beef examined. Duitshaever (1977) showed that more than 50 percent of 108 samples examined were in the range of 5×10^6 to 5×10^7/g. The source of meat