# EFFECTS OF CARCASS ELECTRICAL STIMULATION AND HOT BONING ON SELECTED BEEF MUSCLES

C. L. KASTNER, M. E. DIKEMAN, K. N. NAGELE, M. LYON, M. C. HUNT and D. H. KROPF

Kansas State University, Manhattan, Kansas, U.S.A.

## INTRODUCTION

HOT BONING of beef carcasses has economic advantages (Kastner, 1977; Nason, 1979; Kansas State University, 1980). In addition, proper application of hot boning can yield a product of at least equal quality when compared to that conventionally processed (Kastner, 1977). Muscle excised and chilled or frozen before the onset of rigor mortis can significantly toughen due to pre-rigor excision, cold shortening, or thaw rigor if frozen (Locker and Hagyard, 1963; Marsh et al., 1968; Marsh, 1972; Davey and Gilbert, 1974). Hot-boning research techniques for producing beef steaks and roasts have taken the following approaches. Muscles and muscle systems have been excised within 1 to 2 hr postmortem, then vacuum packaged and conditioned 24 to 48 hr at 15 C or aged for 8 days at 1 C (Schmidt and Gilbert, 1970; Schmidt and Keman, 1974). Alternatively, carcasses were stored at 15 to 16 C for 6 to 10 hr postmortem, then hot boned (Kastner et al., 1973; Kastner and Russel, 1975; Kastner et al., 1976). These hot boning techniques generally equalled or exceeded conventional processing when yield, color, tenderness, and flavor were considered. These approaches to hot boning alleviated potential tenderness problems due to pre-rigor cutting and subsequent temperature treatments, or allowed the onset of rigor mortis before muscle excision.

Electrical stimulation of beef carcasses soon postmortem can speed the onset of rigor mortis (Davey et al., 1976). Therefore, carcass or muscle conditioning or aging periods required for successful hot boning can be reduced or alleviated by electrical stimulation. Consequently, researchers (Gilbert and Davey, 1976; Gilbert et al., 1976; Seideman et al., 1979) have evaluated the utility of electrical stimulation in facilitating hot boning of beef carcasses. This study was designed to further evaluate electrical stimulation and/or hot boning of beef carcasses.

## MATERIALS AND METHODS

### Source of materials and treatments

FORTY-SIX carcasses from 24 Hereford x Angus (medium size biological type, MT) and 22 Simmental x Chianina x Angus or Hereford (large size biological type, LT) steers were utilized in this study. Steers (average weight, 257.6 kg) of each cattle type were assigned by weight to either an accelerated (ACC) or conventional (CONV) feeding regimen after a 4 week adjustment period. The ACC feeding regimen consisted of a high concentrate finishing ration and the CONV regimen consisted of backgrounding on prairie hay, then finishing on a high concentrate ration. Upon finishing, the steers were slaughtered in four different groups: MT ACC, LT ACC, and MT CONV groups, 12 steers each; and LT CONV, 10 steers. These groups are hereafter referred to as management systems.

Treatments assigned to carcass sides were: 1) conventionally chilled at 2 C for 48 hr before fabrication (C), or 2) hot boned at 2 hr postmortem (HB), or 3) electrically stimulated continuously for 2 min at 1 hr postmortem (400 to 600 volts, 5 amps, 60 Hz of AC current) and hot boned at 2 hr postmortem (ESHB). Stimulator probes were inserted on the inside of the rear leg approximately 8 cm below the attachment of the achilles tendon, and anterially to the humerus for ESHB sides. A summary of abbreviations and their explanations are presented in Table 1. Treatment assignments used to evaluate all treatments (C, HB, and ESHB) are presented in Table 2.

TABLE 1. SUMMARY OF ABBREVIATIONS AND THEIR EXPLANATIONS

Management Systems

MT ACC - Medium Size Biological Type, Accelerated Feeding Regimen
LT ACC - Large Size Biological Type, Accelerated Feeding Regimen
MT CONV - Medium Size Biological Type, Conventional Feeding Regimen
LT CONV - Large Size Biological Type, Conventional Feeding Regimen

Treatments

C - Conventional Treatment, Sides Chilled At 2 C Until 48 Hr Postmortem
HB - Hot Boned 2 Hr Postmortem
ESHB - Electrically Stimulated 1 Hr postmortem and Hot Boned 2 Hr Postmortem

TABLE 2. TREATMENT ASSIGNMENTS TO CARCASS SIDES AND MUSCLES

| Carcasses (n=23) | | Carcasses (n=23) | |
|---|---|---|---|
| Side | Side | Side | Side |
| Treatment-C Muscles (LD, SM,TB,PM) | Treatment-ESHB Muscles (LD,SM, TB,PM) | Treatment-C Muscles (LD,SM) | Treatment-ESHB Muscles (LD, SM,TB,PM) |
| | | Treatment-HB Muscles (TB,PM) | |

Muscles

LD - Longissimus dorsi
SM - Semimembranosus
PM - Psoas major
TB - Triceps brachii, long head

Each treatment combination (Table 2) appeared an equal number of times within each management system. It was assumed that hot boning the TB and PM muscles would not affect the C treatment of the LD and SM muscles.

Upon muscle excision, LD, from the anterior tip of the ilium through the 13th rib, SM, TB, and PM muscles were vacuum packaged, boxed and stored at 2 C. Steaks (2.5 cm) for taste panel and Warner-Bratzler shear evaluation were cut from the vacuum aged muscles at 6 days postmortem and frozen at -26 C until evaluated. Color steaks were evaluated before freezing. Color and taste panel evaluations were not conducted on all muscles.

Temperature and pH declines

Postmortem temperature declines (TB and LD muscles) were monitored by inserting a metal stemed dial thermometer into the test muscles to a constant depth of 5 cm. Temperatures were taken at approximately 2, 4, 6, 8, and 24 hr postmortem. TB (lateral head), PM, and LD muscle samples (1.9 cm cores) were removed at 1 hr (prior to electrical stimulation of ESHB sides) and 2, 4, 6, 8, and 24 hr postmortem. A 1 to 2 gm portion of the 1.9 cm core was blended with 10 ml of 5 mM NaIAc in 150 mM KCl (Bendall, 1973), and the pH recorded.

Quality and yield grade and percent lipid in 9-10-11th rib section

USDA quality and yield grades were determined on C sides at 48 hr postmortem. The 9-10-11th rib section was removed, deboned, ground, and sampled for lipid composition (AOAC, 1965).

Warner-Bratzler shear and taste panel evaluations

Taste panel responses were obtained on the LD and SM muscles, whereas all muscles were evaluated for shear force. Steaks were thawed for approximately 16 hr at 2 C before cooking. Both taste panel and shear force steaks were modified oven broiled at 163 C to 70 C internally. Steaks for shear analysis were stored at room temperature (21 C) for 2 hr before coring (AMSA, 1978). A drill press equipped with a 1.27 cm diameter coring device was used to take taste panel and shear force samples perpendicular to the steak surface (Kastner and Henrickson, 1969). Each shear steak yielded six 1.27 cm cores which were sheared once with a Warner-Bratzler apparatus.

Evaluations for myofibrillar tenderness, connective tissue amount, flavor, and juiciness were obtained from a six-member trained taste panel (AMSA, 1978). An eight-point scale was used for each response (8 = extremely tender, intense flavor, or juicy or no connective tissue; 1 = extremely tough, bland flavor, or dry or abundant connective tissue). Eight samples were presented randomly, and no more than two panels met per day.

Color panel evaluations

After oxygenation, LD steaks were placed on a styrofoam tray, overwrapped with polyvinyl chloride film, and displayed for 4 days at 2 C under continuous (24 hr/day) General Electric Delux Warm White flourescent lighting at an intensity of 1076 lumens/$m^2$ (100 foot candles) at the meat surface level.

Subjective muscle color was scored by four panelists. A five-point scale (1 = very bright red; 5 = very dark red or brown) was scored to the nearest 0.5 point (Kropf et al., 1975). A visual score of 3.5 was considered marginally unacceptable.

Statistical analysis

Data were analyzed using the analysis of variance. To determine differences between means, the least significant difference (Snedecor and Cochran, 1973) was used for LD and SM and a linear model approach for the TB and PM muscles (John, 1971).

RESULTS

Carcass characteristics

MT CARCASSES had higher mean yield grades and greater 9-10-11th rib percent lipid compositions than LT carcasses (Table 3). The mean quality grade was average Good for ACC and high Good for CONV feeding regimens.

TABLE 3. USDA MEAN QUALITY AND YIELD GRADES AND 9-10-11th RIB LIPID COMPOSITION BY MANAGEMENT SYSTEMS

| Management Systems | USDA Quality Grade | USDA Yield Grade | 9-10-11th Rib Lipid Composition[a] |
|---|---|---|---|
| MT ACC | Average Good | 3.3 | 41.82 |
| LT ACC | Average Good | 2.3 | 30.83 |
| MT CONV | High Good | 4.0 | 43.00 |
| LT CONV | High Good | 2.3 | 31.88 |

[a] 9-10-11th rib section deboned, ground, and sampled for lipid composition (AOAC, 1965).

Temperature and pH

Our electrical stimulation procedure for ESHB muscles was effective in increasing the rate of pH decline relative to C and HB counterparts (Table 4). However, Davey et al. (1976) observed more rapid pH declines in beef TB, PM, and LD muscles by stimulating sides at 30 min postmortem with 3600 volts, 2 amps, and 15 Hz of AC current.

TABLE 4. MEAN PH, TEMPERATURE AND TIME RELATIONSHIPS BY MUSCLES AND TREATMENTS

| Muscles | Treatments | pH 1 Hr[a] Postmortem | pH 2 Hr[b] Postmortem | Time Postmortem (Hr) when pH = 6.0 | Temperature (C) when pH = 6.0 |
|---|---|---|---|---|---|
| LD | C | 6.70 | 6.38 | 4.0 | 24.2 |
| | ESHB | 6.72 | 6.22 | 3.0 | 29.2 |
| TB[c] | C | 6.86 | 6.69 | 8.0 | 18.9 |
| | HB | 6.72 | 6.63 | 8.0 | 15.6 |
| | ESHB | 6.81 | 6.40 | 5.5 | 24.1 |
| PM | C | 6.21 | 6.10 | 3.0 | ---- |
| | HB | 6.16 | 6.05 | 2.0 | ---- |
| | ESHB | 6.19 | 6.00 | 2.0 | ---- |

[a]Before stimulation of ESHB carcass sides.

[b]Before excision of ESHB and HB muscles.

[c]TB - Triceps brachii, lateral head

Shear force and taste panel

The C shear force mean (Table 5) was not different (P>.05) from its ESHB counterpart for the LD muscle. However, for the SM muscle, the ESHB shear force mean was larger (less tender) and different (P<.05) than the C treatment mean. These results were supported by taste panel myofibrillar tenderness evaluations (Table 5). C and ESHB taste panel myofibrillar tenderness means for the LD muscle were not different (P>.05), but the ESHB mean for the SM muscle was smaller (less tender) and different (P<.05) from its C counterpart. Even so, the ESHB mean myofibrillar tenderness rating for the SM muscle did not fall into the tough category (Table 5).

Generally C and ESHB means for the other taste panel variables for LD and SM muscles were not different (P>.05). However, the ESHB juiciness mean for the LD muscle was larger (more juicy) and different (P<.05) than the C treatment mean.

C vs HB and C vs ESHB shear force treatment mean comparisons for the PM muscle (Table 6) were different (P<.05) in both cases. In addition, HB and ESHB means were smaller (more tender) than C means. HB and ESHB counterparts were not different (P>.05) indicating that electrical stimulation did not improve the hot boning methodology used in this study.

TABLE 5. WARNER-BRATZLER SHEAR FORCE (KG) AND TASTE PANEL MEAN RESPONSES BY VARIABLES AND TREATMENTS FOR LD AND SM MUSCLES

| Variables | Muscles | | | |
|---|---|---|---|---|
| | LD | | SM | |
| | C | ESHB | C | ESHB |
| Shear force | 2.99 | 2.81 | 3.58[a] | 4.13[b] |
| Myofibrillar tenderness[c] | 6.4 | 6.4 | 6.1[a] | 5.7[b] |
| Connective tissue amount[c] | 7.0 | 7.1 | 6.4 | 6.2 |
| Flavor[c] | 6.2 | 6.3 | 6.1 | 6.0 |
| Juiciness[c] | 6.4[a] | 6.6[b] | 5.3 | 5.3 |

[a,b]Means within the same row and muscle bearing different superscripts are different (P<.05).

[c]8 = extremely tender, intense flavor or juicy or no connective tissue;
1 = extremely tough, bland flavor or dry or abundant connective tissue.

TABLE 6. WARNER-BRATZLER SHEAR FORCE MEANS (KG) BY TREATMENTS FOR PM MUSCLE

| Treatments | Means | Comparisons | | |
|---|---|---|---|---|
| | | C vs HB | C vs ESHB | HB vs ESHB |
| C | 2.88 | * | * | ND |
| HB | 2.33 | | | |
| ESHB[1] | 2.33 | | | |
| ESHB[2] | 2.34 | | | |

*Means are different (P<.05).
ND - Means are not different (P>.05).
ESHB[1,2] - When making ESHB comparisons, both ESHB means were used.

Because of a significant management system x treatment interaction, TB shear force treatment mean comparisons are reported by management systems (Table 7). Regardless of the management system, none of the treatment mean comparisons were different (P>.05). Again electrical stimulation was not necessary to insure the success of hot boning. This was true even though electrical stimulation accelerated the rate of pH decline in the TB muscle (Table 4).

Color

Even though no mean color score mean differences (P>.05) existed between the C and ESHB treatments at day 1 or day 4, the ESHB samples tended to be brighter at each day of display (Table 8).

TABLE 7. WARNER-BRATZLER SHEAR FORCE MEANS (KG) BY MANAGEMENT SYSTEMS AND TREATMENTS FOR TB MUSCLE

| Management Systems | Treatments | Means | Comparisons C vs HB | C vs ESHB | HB vs ESHB |
|---|---|---|---|---|---|
| MT ACC | C | 3.57 | ND | ND | ND |
| | HB | 4.18 | | | |
| | ESHB[1] | 3.81 | | | |
| | ESHB[2] | 4.01 | | | |
| LT ACC | C | 3.70 | ND | ND | ND |
| | HB | 4.11 | | | |
| | ESHB[1] | 4.04 | | | |
| | ESHB[2] | 3.83 | | | |
| MT CONV | C | 2.92 | ND | ND | ND |
| | HB | 3.35 | | | |
| | ESHB[1] | 3.57 | | | |
| | ESHB[2] | 3.43 | | | |
| LT CONV | C | 3.40 | ND | ND | ND |
| | HB | 3.93 | | | |
| | ESHB[1] | 3.51 | | | |
| | ESHB[2] | 3.77 | | | |

ND - Means are not different (P>.05).

ESHB[1,2] - When making ESHB comparisons, both ESHB means were used.

TABLE 8. MEAN COLOR PANEL SCORES BY TREATMENTS AND DAYS OF DISPLAY FOR LD MUSCLE

| Days of Display[a] | Treatments C | ESHB |
|---|---|---|
| 1 | 1.65 | 1.54 |
| 4 | 2.10 | 1.94 |

Means within the same row bearing no superscript are not different (P>.05).

Color scale - 1 = very bright red; 5 = very dark red or brown.

[a]Steaks wrapped in polyvinyl chloride film, displayed at 2 C, continuous (24 hr/day) delux warm white flourescent lighting, 1076 lumens/$m^2$ (100 foot candles).

## DISCUSSION

WITH the exception of the SM muscle, our C vs ESHB results generally agree with Gilbert et al. (1976) and Seideman et al. (1979). Our ESHB taste panel means for the SM muscle did not fall into an unacceptable range. Even so, our C vs ESHB shear force and taste panel myofibrillar tenderness mean differences, though small, were significant. Seideman et al. (1979) stimulated at 30 to 40 min postmortem using 25 impluses of 0.5 to 1.0 sec duration and a 2 - week aging period which could have negated the differences (SM muscle tenderness) we observed. Gilbert et al. (1976) also used stimulation conditions (3600 volts of 15 Hz of AC current) which were different from ours. Davey et al. (1976) evaluated the stimulation conditions used by Gilbert et al. (1976) and they were more effective in reducing pH than our stimulation methodology.

Our C vs HB results agree with Schmidt and Keman (1974). Even though electrical stimulation did not appear necessary to successfully hot bone the PM and TB muscles, it may be needed to facilitate the hot boning of other muscles - particularly if an aging or conditioning period is not used.

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