THE EFFECTS OF ELECTRICAL STIMULATION ON RETAIL ACCEPTABILITY AND CASE-LIFE OF BEEF

L. E. JEREMIAH and A. H. MARTIN

Meat Science Section, Canada Dept. of Agric., Research Branch, Lacombe, Alberta

INTRODUCTION

Current widespread interest in electrical stimulation of carcasses has resulted from reports that it significantly enhanced tenderness, improved muscle color, decreased the incidence and severity of "heat-ring" formation, permitted early postmortem muscle removal (hot boning), produced physical disruption of muscle fibers, enhanced the activity of autolytic enzymes, and reduced the effects of "cold shortening" (Cross, 1979). In addition, other workers have also indicated that electrical stimulation could be used to improve certain quality traits of heavy grain-fed beef (Savell et al., 1979), reduce aging time (Strickland et al., 1979a; Savell et al., 1978b,c), and allow carcasses to be graded sooner (Savell et al., 1978b,c). Furthermore, Gilbert and Davey (1976) reported that early postmortem muscle removal (hot boning) conserved chilling space and processing time and permitted automation of subsequent meat handling; and Jeremiah (1978) indicated that the use of electrical stimulation may have practical application in the meat industry, since it was suited to continuous chain operation and required little additional labor or kill floor space.

McLoughlin (1970) reported that neural stimulation at death was the major factor involved in rapid postmortem glycolysis; and Gilbert et al. (1977) indicated that acceleration of postmortem glycolysis by electrical stimulation permitted rapid chilling to retard microbial growth, thereby resulting in a more wholesome product, which would presumably have longer shelf-life. Various other workers have indicated that electrical stimulation lengthens retail case-life (Riley et al., 1979, 1980), brightens lean color (Calkins et al., 1979; Cross, 1979; Cross et al., 1978, 1979a; Hall et al., 1979; McKieth et al., 1979a,b; Ray et al., 1978; Riley et al., 1979, 1980; Savell et al., 1978a,b,c; Stiffler et al., 1978), produces whiter fat (Cross et al., 1979b), and improves uniformity of lean color (Savell et al., 1979) without producing other deleterious effects (Chrystall and Hagyard, 1976; Hall et al., 1979). However, other workers have failed to observe improvements in lean color (Grusby et al., 1976; Grusby and West, 1977; Nichols and Cross, 1978; Smith et al., 1979; Stiffler and Ray, 1979; Strickland et al., 1979b), uniformity of lean color (Nichols and Cross, 1978), amount of free moisture (drip) in the packages during display (Hall et al., 1979), or psychrotrophic counts prior to and following display (Hall et al., 1979; Schroeder et al., 1978) from electrical stimulation, or have reported that improvements in lean color produced by electrical stimulation may be negated by 48 hr or more of chilling (Calkins et al., 1979).

The present study was designed to evaluate the effects of electrical stimulation after splitting and prior to chilling on the retail acceptability and case-life of boneless rib steaks from heavy grain-finished beef.

MATERIALS AND METHODS

A total of 25 cattle (5 purebred Simmental, Limousin, or Chianina bulls and 10 each of steers and heifers (1/2 blood Simmental, Limousin, or Chianina)) 11 to 15 months of age and with carcass weights of approximately 270 kg, after approximately 255 days on a high concentrate ration, were utilized to evaluate the effects of electrical stimulation upon the retail acceptability and case-life of boneless rib steaks. After splitting each carcass into sides, electrode clamps were affixed to the muscles of the round below the Achilles tendon and to the exposed muscles in the neck of the right side. This side was then electrically stimulated at 400V (AC-50 to 60 cycles/sec) using a Best and Donovan #E2333 hog stunner with a maximum output of 5 amps, attached to a HJ8015 Juno multimeter, while the left side served as the unstimulated control. Stimulation was applied in pulses. Each pulse was continued until the muscles of the side appeared to relax (3-10 sec). The number of pulses per side (mean number of pulses = 7.2 bulls; 9.9 heifers; 8.9 steers; range = 5 to 14) depended upon the number of pulses required to illicit essentially no visible response from the final pulse. Mean intervals during which stimulation was applied, from the beginning of the first pulse to the end of the final pulse, including approximately 2 sec recovery periods between pulses, were 90, 110, and 100 sec, respectively, for bulls, heifers, and steers (range = 45 to 170 sec). Following stimulation all sides were chilled for 6 days at 2°C. A 3 cm thick boneless rib steak was then removed from the area of the sixth thoracic vertebra of each side.

Each steak was weighed, placed in a polystyrene tray, heat sealed in Vitafilm Choice Wrap (MVTR = 22 g/2540 cm^2/24 hr; O_2TR = 555 cc/2540 cm^2/24 hr; CO_2TR = 4720 cc/2540 cm^2/24 hr), and displayed for 96 hr (4 days) in a self-service retail display case (Hill Refrigeration of Canada, Ltd.) at 2°C under 820 lx of incandescent lighting. All steaks were evaluated daily for muscle color, amount of discoloration, and retail acceptability, by a trained and experienced 3-member panel, and for the presence of off-odors at the conclusion of the display period, by an experienced evaluator, using the scales presented in Table 1. Log_{10} psychrotrophic counts were obtained prior to and immediately following retail display by swabbing 2 cm^2 of the surface of each steak, plating on standard plate count agar (Difco Laboratories, Detroit, Mich.), and incubating plates for 10 days at 1°C. Both the steaks and the free moisture (drip) in the packages were weighed at the conclusion of the display period to determine the amount of drip loss during display. Data were analysed using the Student "t" test for paired comparisons to determine the significance of numerical differences between means (Steele and Torrie, 1960).

Table 1. Sensory evaluation scales utilized

Muscle Color Scale	Discoloration Scale	Retail Acceptance Scale
1. White	1. No surface discoloration	1. Extremely undesirable
2. Pale pink	2. 1-10% surface discoloration	2. Unsaleable
3. Moderately pale pink	3. 11-25% surface discoloration	3. Slightly undesirable
4. Slightly pale red	4. 26-50% surface discoloration	4. Neither desirable nor undesirable
5. Bright "cherry" red	5. 51-75% surface discoloration	5. Slightly desirable
6. Slightly dark red	6. 76-100% surface discoloration	6. Desirable
7. Moderately dark red	7. Brown or black	7. Extremely desirable
8. Extremely dark red	8. Green or grey	
9. Brown or Black		Odor Scale
10. Green or Grey		1. No detectable off-odor
		2. Slightly detectable off-odor
		3. Prevalent off-odor

RESULTS AND DISCUSSION

Muscle color: Muscles derived from both electrically stimulated and control sides became progressively darker as the duration of retail display was extended (Figure 1). However, there were no significant differences ($P>0.05$) in muscle color when treated and control sides were compared initially (prior to display) or daily during 4 days of retail display in any of the sex groups. Although these findings are compatible with previous reports of nonsignificant color differences between stimulated and unstimulated meat (Grusby et al., 1976; Grusby and West, 1977; Nichols and Cross, 1978; Smith et al., 1979; Stiffler and Ray, 1979; Strickland et al., 1979b), they appear contrary to other reports that electrical stimulation increased the brightness of the lean color (Calkins et al., 1979; Cross, 1979; Cross et al., 1978, 1979a; Hall et al., 1979; McKieth et al., 1979a,b; Ray et al., 1978; Riley et al., 1979, 1980; Savell et al., 1978a,b,c; Stiffler et al., 1978). However, the numerical difference ($P>0.05$) observed in the present study, particularly for steers ($P<0.10$ after 2 and 3 days of retail display), may lend some support to these previous observations. It should be noted that samples in the present study were evaluated after at least 6 days of postmortem aging, while many previous evaluations took place at 24 hr postmortem; and that Calkins et al (1979) reported that improvements in lean color observed at 24 hr attributable to electrical stimulation may be negated by 48 hr or more of chilling.

Discoloration: Discoloration of boneless rib steaks progressed at similar rates, for stimulated and unstimulated samples from bulls, steers, and heifers, during 4 days of retail display. Significant ($P<0.05$) differences between discoloration scores of stimulated and unstimulated samples were not observed initially or after any of the retail display intervals observed (Figure 2). Such findings imply that electrical stimulation had little effect on the rate of discoloration of boneless rib steaks.

Retail Acceptance: Retail acceptability of boneless rib steaks did not differ significantly ($P>0.05$) due to electrical stimulation initially (prior to display) or after any of the retail display intervals observed, within any of the sex groups (Figure 3). Moreover, stimulated and unstimulated samples from all sexes followed similar patterns of decline in retail acceptability during 4 days of retail display. These findings appear to be at variance with other reports that electrical stimulation produced improvement in retail appearance (Hall et al., 1979; Riley et al., 1979, 1980), although the consistantly higher numerical differences observed in retail acceptance scores for steaks from stimulated steer carcass sides appear to be in accord with such reports. The fact that steaks from stimulated steer carcass sides took approximately 0.2 days longer to reach the point of unacceptability (retail appearance score = 3.5) than steaks from unstimulated steer carcass sides agrees with the reports of Riley et al. (1979, 1980) that electrical stimulation extended the retail case-life of meat. However, the fact that steaks from stimulated bull carcass sides were unacceptable approximately 0.12 days earlier than steaks from unstimulated bull carcass sides tends to refute such a conclusion. The fact that stimulated and unstimulated steaks from heifers reached the point of unacceptability (retail acceptance score = 3.5) at approximately the same time during retail display agrees with reports of other workers (Hall et al., 1979; Schroeder et al., 1978) that electrical stimulation did not alter the retail case-life Therefore, the effect that electrical stimulation has on the retail case-life of beef appears to be sex dependent but of little practical significance.

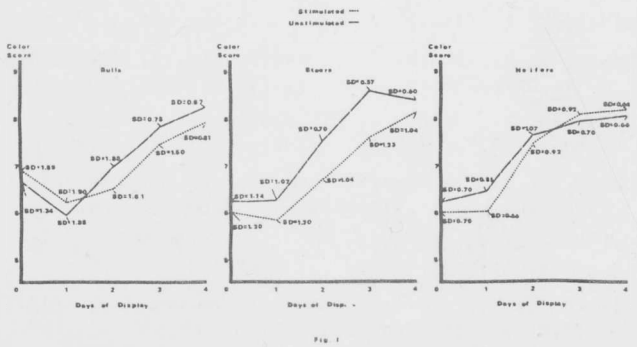

Fig. 1. Effect of electrical stimulation on muscle color scores of boneless rib steaks during retail display.

Psychrotrophic Counts: The $\log^{10}$ psychrotrophic counts did not differ significantly ($P>0.05$) between stimulated and unstimulated from bulls, steers, or heifers either initially or following the 4 day display period (Table 2). These results substantiate the previous report of Hall et al. (1979) that psychrotrophic counts, either prior to or following retail display, were not influenced by electrical stimulation. However, other workers have reported significant differences in psychrotrophic counts produced by electrical stimulation (Raccach and Henrickson, 1978).

Incidence of Off-Odors and Amount of Drip in the Package: Neither odor scores nor the amount (percent) of free moisture (drip) in the packages differed significantly ($P>0.05$) for boneless rib steaks in any of the sex groups (Table 3). Therefore, these findings support the reports of Hall et al. (1979) and Morgan (1979) that electrical stimulation did not alter the amount of free moisture (drip) in the packages during retail display.

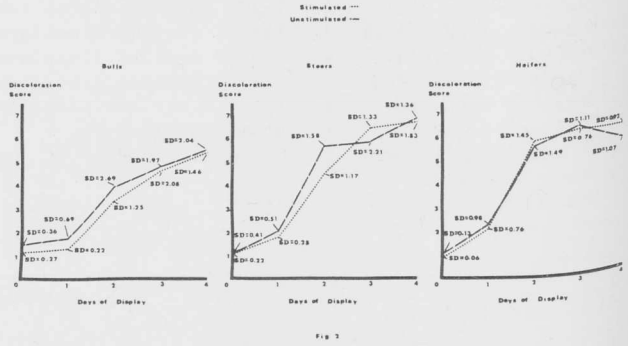

Fig. 2. Effect of electrical stimulation on discoloration scores of boneless rib steaks during retail display.

The composite results of the present study indicate that with the type of cattle evaluated and under the conditions in which the study was conducted electrical stimulation did not produce sufficient improvements in either retail acceptability or retail case-life to be of practical significance. Therefore, electrical stimulation may be of little value for enhancing the retail acceptability or extending the retail case-life of beef, when it takes 6 days or longer to reach the retail counter as is often the case in North America. However, if the technique can be utilized to accelerate chilling to permit reduction in microbial loads and facilitate more rapid grading and shipment of carcasses, obvious advantages become apparent. Likewise, if the technique can be utilized to accelerate the aging process to provide an acceptable product with less cooler storage, other advantages are obvious. Further research in these areas may be quite beneficial.

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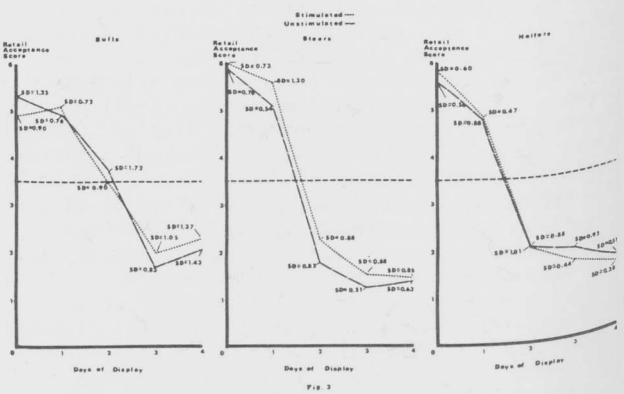

Fig. 3. Effect of electrical stimulation on retail acceptability scores of boneless rib steaks during retail display.

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Table 2. Log^{10} psychrotrophic plate counts from boneless rib steaks taken from stimulated and unstimulated beef sides prior to (6 days postmortem) and following 4 days of retail display (10 days postmortem)[1,2]

		Day of Retail Display			
		Day 0		Day 4	
Sex	Treatment	X	SE	X	SE
Bulls	Stimulated	4.40[a]	0.25	6.29[a]	0.26
	Unstimulated	4.46[a]	0.29	6.22[a]	0.23
Steers	Stimulated	4.03[a]	0.17	6.74[a]	0.38
	Unstimulated	3.76[a]	0.15	6.94[a]	0.26
Heifers	Stimulated	3.77[a]	0.11	6.82[a]	0.26
	Unstimulated	4.02[a]	0.10	6.75[a]	0.28

[1]Means in the same sex group and same column bearing a common superscript do not differ significantly (P>0.05).

[2]Log^{10} counts per cm^2.

Table 3. Means and standard errors for odor scores and percent free-moisture (drip) in the packages from boneless rib steaks taken from electrically stimulated and unstimulated beef sides after 4 days of retail display[1].

		Trait			
		Odor Score		Percent Free-Moisture (Drip)	
Sex	Treatment	$\bar{X}$	SE	$\bar{X}$	SE
Bulls	Stimulated	2.60[a]	0.24	0.08[a]	0.03
	Unstimulated	2.40[a]	0.24	0.11[a]	0.03
Steers	Stimulated	2.70[a]	0.15	0.11[a]	0.02
	Unstimulated	2.70[a]	0.15	0.18[a]	0.04
Heifers	Stimulated	2.80[a]	0.13	0.34[a]	0.11
	Unstimulated	2.60[a]	0.16	0.34[a]	0.09

[1]Means in the same sex group and same column bearing a common superscript do not differ significantly (P>0.05).