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CONVENTIONAL VERSUS ACCELERATED BEEF PRODUCTION WITH CARCASS ELECTRICAL STIMULATION[1,2]

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ABSTRACT

Sixty-four 8-mo-old steers, produced from 7/8 Simmental sires mated to crossbred dams, averaged 265 kg initial weight. Forty-eight steers were assigned to an Accelerated (ACC) production system, while 16 steers were assigned to a Conventional (CONV) production system. Steers on the ACC system were fed an 85% concentrate diet; steers on the CONV system were backgrounded for 110 d on a high silage diet and then finished on an 85% concentrate diet. The ACC steers were slaughtered in three groups at average weights of 438, 492 and 554 kg; CONV steers were slaughtered at 591 kg. Days-on-feed were 139 (ACC-I), 174 (ACC-II), 242 (ACC-III) and 284 (CONV), respectively. At slaughter, one side of the carcass was pulse-electrically stimulated (ES) with 400 V at 45 min postmortem and the other side served as a nonelectrically stimulated control (C). Semimembranosus (SM) and longissimus (LD) C and ES steaks were removed at 48 and 24 h postmortem, respectively, vacuum packaged, aged 6 d at 2 C, frozen and later thawed for trained sensory panel and Warner-Bratzler shear (WBS) evaluations. Overall average daily gains were not different among slaughter groups, but CONV steers gained faster ($P<.05$) during the finishing phase than ACC steers. Metabolizable energy:gain ratios were not different among treatments, but dry matter:gain ratios were higher ($P<.05$) for CONV steers than for ACC-I and ACC-II steers. The CONV steers had lower ($P<.05$) dressing percentages than ACC-II and ACC-III steers. Lipid of the 9-10-11th rib section was higher ($P<.05$) and protein and water were lower ($P<.05$) for ACC-III than for ACC-I and ACC-II steers, but not different ($P>.05$) from CONV steers. Electrical stimulation decreased ($P<.05$) 2-, 4- and 6-h pH readings. The LD steaks from ACC-II and ACC-III steers were at least equal in all sensory traits, except juiciness, to those from CONV steers. The SM steaks from CONV steers had the highest WBS force and lowest sensory scores. Electrical stimulation decreased ($P<.05$) LD myofibrillar and overall tenderness scores, but had no effect on SM palatability.

(Key Words: Bovidae, Performance, Carcasses, Nutrition, Palatability, Electrical Treatment.)

Introduction

Economic pressures to improve production efficiency have prompted the beef-cattle industry and researchers to evaluate different production systems. Feeding grain diets to cattle is generally considered to result in meat that is more tender, flavorful and juicy than that of forage-fed cattle. Most cattle feeders strive to feed cattle to sufficient fatness so that a high percentage will be graded USDA Choice because of the price advantage of Choice carcasses. Yet, feeding to the Choice grade is inefficient because of the energy expense of fat deposition relative to muscle growth (Thorbek, 1977).

Feeding cattle for maximum rate of gain increases feed efficiency because of the dilution of maintenance requirements (Dikeman, 1973) and decreases nonfeed costs per unit of gain (Myers et al., 1979). Therefore, feeding for maximum rate of gain and terminating the feeding period when cattle have depositied a minimum amount of trimmable fat results in optimum feed efficiency.

Some studies indicate that feeding a grain diet for a minimum of 100 d results in desirable meat palatability. Dikeman et al. (1985) demonstrated that feeding cattle a high-concen-

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trate diet beginning shortly after weaning, but slaughtering them when a high percentage graded USDA Good, resulted in equal meat palatability and superior efficiency to cattle on a conventional production system fed to the Choice grade.

Electrical stimulation (ES) has received considerable attention as a method for improving meat quality. New Zealand researchers were among the first to demonstrate an improvement in tenderness from ES, primarily attributable to the prevention of cold toughening (Chrystall and Hagyard, 1975; Davey et al., 1976; Chrystall, 1976). Savell et al. (1978a) proposed that ES caused certain structural changes that increased tenderness. Several studies have shown that pulsed stimulation is more effective in accelerating postmortem glycolysis than nonpulsed stimulation. Some researchers (Jeremiah and Martin, 1980; Marsh, 1983) have not found the frequently reported benefits of ES on longissimus (LD) muscle.

There is a void in published research concerning the effects of accelerated production on performance, carcass and especially meat sensory traits. Furthermore, most research does not contain both performance and carcass data. Our research was designed to investigate conventional and accelerated production systems and their effects on performance, carcass and meat sensory traits and to investigate whether ES enhances meat quality.

Materials and Methods

Sixty-four large-type, crossbred steers, produced from mating 7/8 Simmental sires to crossbred dams (crosses of Continental and British breeds), were purchased from the R. L. Hruska U.S. Meat Animal Research Center at Clay Center, Nebraska and delivered to the Kansas State University Beef Research Unit. These spring-born steers were approximately 8 mo old and averaged 265 kg when purchased. Weights recorded after the steers were unloaded from the truck were used as shrunk, starting weights.

Steers were stratified by both weight and weight per day of age, and then allotted to 12 pens of uniform average weights with similar weight variations. Nine pens containing 48 steers were assigned to the Accelerated (ACC) production system, which did not include a growing period, and the remaining three pens containing 16 steers were assigned to the Conventional (CONV) production system, which included a growing period followed by a finishing period.

Upon arrival, the ACC steers were placed on a 7-d adjustment diet (diet 1, table 1). On d 8, steers were placed on diet 2 and on d 14, diet 3. The first three diets involved a continuous change to the higher concentrate diet 4. The soybean meal portion of the diet was decreased as the feeding period progressed because of decreasing protein requirements. Diet compositions are shown in table 1. The CONV steers were fed a high-silage diet that gradually increased in energy density for 110 d before being fed the prefinishing adjustment diet for 23 d. Diet 4 was then fed 174 d until slaughter.

Steers were fed twice daily and their consumption by pen monitored to maintain ad libitum feeding and yet to keep fresh feed before them. Feed samples of forage sorghum silage (FSS) were taken periodically to determine dry matter percentages. For corn, soybean meal (SBM), protein and mineral supplement, NRC (1976) dry matter values were used throughout the feeding period. The diet was balanced to meet NRC (1976) requirements.

Weights were recorded individually at 28-d intervals before the morning feeding throughout the trial, except that the last weigh period varied slightly from 28 d due to scheduling of slaughter in the Kansas State University meat laboratory. Steers were not fed or watered for 16 h before final weights were taken.

The first of three slaughter end points for ACC steers was designated as 453.6 kg to simulate the "hamburger" steer and(or) a quality-grade end point of low Good. ACC-III steers were designated to be slaughtered at 567 kg to simulate a quality-grade mix of 70% Choice, 30% Good. The ACC-II steers were slaughtered at a weight midway between ACC-I and ACC-III. The CONV steers were designated to be slaughtered at 590 kg, also to simulate a quality-grade mix of 70% Choice, 30% Good. Actual slaughter weights are presented in table 2. When the three pens of steers reached their assigned weight end point, they were slaughtered. Two CONV steers that became ill and showed severe performance reduction were removed from the study.

One side of each carcass was randomly assigned to an ES treatment and the other side served as a nonstimulated control (C). The ES sides were pulse-stimulated (1.6 s on, .8 s off) for 2 min at 45 min after bleeding using 400 V,

TABLE 1. DIET COMPOSITIONS FOR ACCELERATED AND CONVENTIONAL STEERS

Ingredient[a]	ACC Diet 1	ACC Diet 2	ACC Diet 3	ACC Diet 4	CONV growing[b]	CONV adjustment[b]	CONV finishing
Corn (IFN 4-02-931), %	44.5	58.1	72.3	84.4	0 → 9.7	42.6 → 52.1	84.9
Forage sorghum silage (IFN 3-04-468), %	45.3	33.0	19.6	9.6	82.9 → 74.6	46.6 → 39.7	9.1
Soybean meal (IFN 5-04-604), %	8.0	3.0	1.9			8.1 → 2.7	
Supplement, %[c]	2.3	5.9	6.2	6.0	17.1 → 15.8	2.8 → 5.5	6.0
Days	7	6	45	81, 120 or 184	110	23	151
Crude protein, %	12.72	12.18	12.22	11.67	13.10 → 12.93	12.89 → 11.72	11.69
Metabolizable energy, Mcal/kg[d]	2.66	2.76	2.92	3.05	1.94 → 2.04	2.64 → 2.68	3.05

[a]Values are expressed on a dry-matter basis.

[b]Sorghum silage was gradually reduced while corn was gradually increased.

[c]Contained 42.8% crude protein, 1.9% calcium, 1.4% phosphorus, and supplied 200 mg of Rumensin per steer daily.

[d]NRC (1976).

60 Hz AC current with approximately 1 amp transmitted through the carcass.

Core samples 1.27 cm in diameter were excised from the LD (opposite the fifth lumbar vertebrae) and semimembranosus (SM, 2.5 cm above the aitch bone) muscles for pH determinations at 45 min (before stimulation) and at 2, 4, 6, 8, 10 and 24 h postmortem. One to 2 g of muscle were blended with 10 ml of 5 mM sodium iodoacetate in 150 mM KCl (Bendall, 1973) for pH determination.

The USDA yield-grade (YG) and quality-grade (QG) data were collected after chilling at 3 to 5 C for 24 h and quality grade was re-evaluated at 48 h postmortem. In addition, soft tissue of the 9-10-11th rib section was used to estimate carcass chemical composition (Hankins and Howe, 1946). The inside round and strip loin from ES and C sides were removed at 24 and 48 h, respectively, cut into 2.5-cm-thick SM and LD steaks and vacuum packaged. These steaks were aged 6 d at 2 C before being frozen and stored at −26 C for subsequent sensory evaluation and Warner-Bratzler shear (WBS) determinations. Statistically randomized selections of sensory-panel steaks from the four slaughter groups and two carcass treatments were made before cooking and were designed to eliminate any storage-period (maximum of 50 d) differences between slaughter groups.

Both sensory-panel and WBS steaks for C and ES treatments were thawed for 18 h at 2 C, trimmed to .25 cm subcutaneous fat and modified-oven-broiled (AMSA, 1978) in a 163 C oven to an internal temperature of 70 C monitored by thermocouples. Taste-panel and WBS samples were taken perpendicular to the steak surface by use of a drill press equipped with a 1.27-cm-diameter coring device and kept warm in small double-boiler pans partially filled with warm water. Six cores were taken from each WBS steak and sheared once to determine peak force. An eight-member trained sensory panel was used to evaluate steaks for flavor, myofibrillar tenderness, connective tissue amount, juiciness and overall tenderness according to AMSA (1978). Panelists were positioned randomly in individual booths equipped with red fluorescent lighting. Eight samples were presented in a statistically randomized order and no more than two sessions were conducted per day.

Data were analyzed by least-squares analysis of variance and corresponding F tests. Means were separated with least-squares procedures

TABLE 2. NUMBERS OF STEERS, FEEDING TIMES, PLANNED AND ACTUAL SLAUGHTER WEIGHTS FOR ACCELERATED AND CONVENTIONAL PRODUCTION SYSTEMS[a]

Number within pens	Diet	Planned slaughter weight, kg		Actual slaughter weight, kg
			ACC-I	
5 steers 5 steers 5 steers	Finishing, 139 d	453.6		438
			ACC-II	
6 steers 5 steers 5 steers	Finishing, 178 d	510.3		492
			ACC-III	
5 steers 6 steers 5 steers	Finishing, 242 d	567		554
			CONV	
5 steers 5 steers 5 steers	Growing, 110 d; finishing, 174 d	590		591

[a]Two steers had to be removed due to chronic illness and injury.

(Snedecor and Cochran, 1978). The analysis was performed by using the General Linear Models procedure on the Statistical Analysis System (SAS, 1979).

Results and Discussion

CONV and ACC Production Effects on Steer Performance. The ACC steers were on feed for 139, 178 and 242 d, respectively. The CONV steers were on feed 284 d; the growing phase was 110 d, the adjustment phase was 23 d and the finishing phase was 174 d (table 2). Therefore, it is not surprising that ACC slaughter weights and total gains were different ($P<.05$, table 3) among slaughter groups because of our planned end points.

There were no differences ($P>.05$) among slaughter groups in overall average daily gain (ADG, table 3), although ACC-II steers tended ($P=.08$) to gain faster than CONV steers. Therefore, these large-type steers maintained their ADG over a relatively long feeding period. Lancaster et al. (1973) reported no difference in ADG between ACC and CONV steers over a feeding period of 156 d due to an increased intake and performance by CONV steers over the second half of the feeding period. Harris et al. (1979) also reported no difference in overall ADG between ACC and CONV Hereford steers over a 174-d feeding trial, but ACC steers had higher ADG than CONV steers during the first half of the feeding trial. An ADG decrease from 139 to 251 d also was reported by Stringer et al. (1968) for ACC steers, but not for CONV steers.

When we compared CONV steers over the finishing phase only (CONV-finishing) with ACC steers, CONV steers gained faster than ACC-II and ACC-III steers. This probably was due to compensatory gain and agrees with the report by Lancaster et al. (1973) that CONV-finished steers outperformed ACC steers over the last 76 d of a 156-d feeding period.

Overall dry matter feed efficiency (total pen DM intake/total pen gain, G), expressed as DM/G, was superior ($P<.05$) for ACC-I and ACC-II steers than for CONV steers. In addition, ACC-I and ACC-II steers tended ($P=.07$) to have better dry matter feed efficiency than ACC-III steers. The ACC-III and CONV steers had higher maintenance-energy requirements and greater requirements for depositing tissue because they were heavier and were depositing more fat (Dikeman, 1973; Lipsey et al., 1978; Loveday and Dikeman, 1980; Marion et al., 1980). Lancaster et al. (1973) and Dikeman et al. (1985) reported that ACC steers were more efficient than CONV steers. Smith et al. (1976) stated that differences in feed:gain ratios (F/G) may be due to variation in days for maintenance since they found that 88% of the variation in F/G was due to days-on-feed when fed to a constant weight.

TABLE 3. LEAST-SQUARES MEANS FOR PERFORMANCE OF ACCELERATED AND CONVENTIONAL PRODUCTION SYSTEMS

	Accelerated			Conventional	
Trait	I	II	III	Overall	Finishing phase[a]
Starting weight, kg	266.6	263.9	261.0	266.7	360.8
Final weight, kg	438.3[b]	491.7[c]	553.9[d]	591.3[e]	591.3
Total gain, kg	171.7[b]	227.8[c]	292.9[d]	324.6[e]	230.5
Days on feed	139[b]	178[c]	242[d]	284[e]	174
Avg daily gain, kg/d					
Overall	1.23	1.28	1.21	1.14	
139 d to slaughter		1.12[b]	1.14[b]		1.34[c]
Feed efficiency, DM intake/kg gain					
Overall	6.16[b]	5.87[b]	6.63[b]	7.00[c]	
139 d to slaughter		7.06[b]	7.56[b]		6.90[b]
Feed efficiency, ME/kg gain					
Overall	18.39[bc]	17.57[b]	19.98[c]	18.72[bc]	
139 d to slaughter		21.32	23.09		21.06

[a]Finishing phase only.

[b,c,d,e]Means in same row for ACC and CONV overall slaughter groups that do not have a common superscript differ (P<.05).

Lancaster et al. (1973) reported that feed consumption of CONV steers increased dramatically (2.6 kg more feed per day in the finishing phase) compared with ACC steers.

Metabolizable energy:gain ratio (ME/G) was higher (P<.05) for ACC-III steers than for ACC-II steers. The ACC-II steers had equal gains to ACC-III steers, but had lower maintenance needs and were depositing less fat. The ACC-I and CONV steers were equal in ME/G. Smith et al. (1977) reported that ME/G did not vary when diet energy increased from 2.18 to 3.11 Mcal ME/kg.

CONV and ACC Production Effects on Carcass Traits. Because average live weight was used to determine slaughter end points, hot-carcass weights (HCW) were different (P<.05) among ACC slaughter groups (table 4). However, it was surprising that HCW between ACC-III and CONV steers were not different because mean live weights were different (P<.05). The 4.2% advantage (P<.05) in dressing percentage for ACC-III steers over CONV steers was unexpected. The 3.0% advantage for ACC-II steers over ACC-I steers can be explained partially by increased fatness and a decreased proportion of noncarcass parts. Stringer et al. (1968), Hedrick et al. (1969) and Zinn et al. (1970) all reported that increased fatness increased dressing percentage. On that basis, the CONV steers should have had higher dressing percentages than ACC-II steers because they were fatter (higher kidney, heart and pelvic fat percentages, adjusted fat thicknesses and 9-10-11th rib fat content) than ACC-II steers. No explanation can be offered for the differences in dressing percentages among ACC-II, ACC-III and CONV steers.

Adjusted fat thickness tended to increase (P=.08) from ACC-I to ACC-II (.69 vs .89 cm) and from ACC-II to ACC-III (.89 vs 1.08 cm). The CONV steers also tended (P=.10) to have greater fat thickness than ACC-III steers (1.25 vs 1.08 cm, respectively). Kidney, pelvic and heart (KPH) fat percentage was higher (P<.05) for CONV than for ACC-I and ACC-II steers, and ACC-III steers tended (P=.07) to have more KPH fat than ACC-I and ACC-II steers. Numerous researchers have found an increase in fat thickness and KPH fat with an increase in time-on-feed.

Longissimus area (LEA) from ACC-I to ACC-III also increased (P<.05). Because YG is highly influenced by LEA, adjusted fat thickness and KPH fat (all of which were significantly affected by slaughter group), it is not surprising that YG also was affected (P<.05) by slaughter group.

Marbling at 48 h did not differ between ACC-I and ACC-II steers, whereas ACC-III steers had distinctly more ($P<.05$) marbling than ACC-I and ACC-II steers. ACC-III and CONV steers did not differ in marbling. Bone and lean maturity were higher for ACC-III and CONV steers than for ACC-I and ACC-II steers. Quality grades were higher ($P<.05$) for ACC-III and CONV steers than for ACC-I and ACC-II steers. Stringer et al. (1968), Hedrick et al. (1969), Moody et al. (1970) and others found a positive relationship between time-on-feed and marbling score. Because of this positive relationship, we expected the longer-fed (242 d) ACC-III steers to attain the same marbling at a lighter weight than the CONV steers fed the finishing diet 174 d. Equal marbling scores in table 4 and essentially equal percentages of Choice carcasses (56 vs 61%, data not shown) confirm our expectation.

Hankins and Howe (1946) reported that the 9-10-11th rib-section soft-tissue composition can be used to predict accurately carcass composition. In our study, the 9-10-11th rib percentages of water and ether extract (EE) were the same ($P>.05$) for ACC-I and ACC-II and also for ACC-III and CONV carcasses (table 4). Percentages of protein decreased ($P<.05$) from ACC-I to ACC-III, whereas ACC-III and CONV were not different. Bowling et al. (1978) reported an increase in EE of ACC cattle by grain feeding. Forrest et al. (1975) stated that as the percentage of lipid in adipose tissue increased, the percentages of water, protein and other constituents decreased. In our study, EE and water were highly negatively related ($r = -.99$) compared with protein and water ($r = .69$) or protein and EE ($r = -.65$).

ES Effects on Carcass Traits. Illustrated in figures 1 and 2 are pH and temperature declines for LD and SM muscles. It is obvious that ES was effective in speeding the rate of pH decline. Temperature declines were similar for C and ES muscles. Neither muscle reached the cold-toughening conditions of 10 C in less than 10 h postmortem (Locker and Hagyard, 1963), or

TABLE 4. EFFECTS OF ACCELERATED AND CONVENTIONAL PRODUCTION SYSTEMS ON CARCASS CHARACTERISTICS

Trait	Accelerated I	Accelerated II	Accelerated III	Conventional
Hot carcass weight, kg	263.0[d]	310.0[e]	356.3[f]	355.1[f]
Dressing percentage	60.0[d]	63.0[e]	64.3[e]	60.1[d]
Adjusted fat thickness, cm	.69[d]	.89[de]	1.08[e]	1.25[f]
Kidney, pelvic & heart fat, %	2.1[d]	2.2[d]	2.4[de]	2.5[e]
Longissimus area, cm^2	68.9[d]	74.4[e]	82.4[f]	82.2[f]
Yield grade	2.3[d]	2.6[de]	2.9[ef]	3.1[f]
Bone maturity[a]	35.0[d]	38.8[d]	52.5[e]	50.0[e]
Lean maturity[a]				
C	36.3[d]	32.5[d]	40.0[d]	53.8[e]
(ES)	27.8[d]	32.8[d]	42.8[e]	42.5[e]
48-h marbling[b]				
C	7.0[d]	7.3[de]	9.0[e]	8.8[de]
(ES)	7.1[d]	7.4[d]	9.7[e]	9.7[e]
Quality grade[c]				
C	8.0[de]	7.8[d]	9.3[f]	9.0[ef]
(ES)	8.0[d]	8.2[d]	9.7[e]	9.6[e]
9-10-11th rib section				
Rib weight, kg	4.4[d]	5.2[e]	6.5[f]	6.6[f]
Bone weight, kg	.8[d]	.9[de]	1.0[e]	1.1[f]
Soft tissue weight, kg	3.6[d]	4.3[e]	5.5[f]	5.5[f]
Water, %	52.7[e]	51.8[e]	47.5[d]	46.5[d]
Ether extract, %	31.5[d]	32.4[d]	36.8[e]	39.9[e]
Protein, %	16.1[f]	15.4[ef]	14.6[de]	13.8[d]

[a]Percentage within A maturity.

[b]7 = Sl^-, 8 = Sl°, 9 = Sl^+, 10 = Sm^-.

[c]7 = St^+, 8 = G^-, 9 = G^+, 10 = Ch^-.

[d,e,f]Means in the same row that do not have a common superscript differ ($P<.05$).

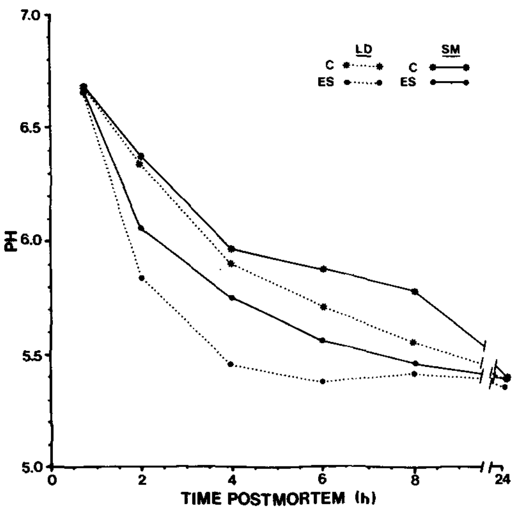

Figure 1. Postmortem pH declines for control (C) and electrically stimulated (ES) longissimus (LD) and semimembranosus (SM) muscles.

before pH 6.0 was reached (Chrystall, 1976). On the contrary, our chill conditions were mild enough that protein denaturation may have occurred in the ES sides.

Electrical stimulation did not significantly affect 24- or 48-h marbling or QG, although values tended to be higher for ES sides (table 5). Even though there was no significant slaughter group × carcass treatment interaction, it appeared that ES increased marbling of the more highly marbled steers (ACC-III and CONV) more than ACC-I and ACC-II steers (table 4). Cross et al. (1979), Cross and Tennent (1980) and Greathouse et al. (1983) reported no effect of ES (150 to 400 V, 1.5 amp, 60 Hz) on QG; whereas McKeith et al. (1981), Savell et al. (1982) and Orcutt et al. (1984) reported that quality-indicating characteristics of beef were improved with ES.

Lean firmness decreased (P<.05) with ES, which agrees with the findings of Greathouse et al. (1983). Neither lean maturity, lean color nor lean texture was affected by ES. Bendall and Rhodes (1976) hypothesized that if pH values fell below 6.0 within 1.5 h postmortem while the deep-muscle temperature was above 35 C, a pale, soft and exudative condition could occur. This may have occurred in the LD muscle in our study. Savell et al. (1978b), Cross and Tennent (1980) and Savell et al. (1982) reported improvements in lean maturity from ES compared with controls. Lean color has been improved by ES in studies conducted by Smith et al. (1977) and Savell et al. (1978b). Davey et al. (1976) reported no influence of ES on texture of strip loins or SM steaks.

ACC and CONV Production Effects on Palatability Traits. The LD steaks from CONV steers were juicier (P<.05) than steaks from ACC-I and ACC-III steers, but had more (P<.05) detectable connective tissue than LD steaks from ACC-I and ACC-II steers (table 6). The LD steaks from ACC-III steers also had more detectable connective tissue than steaks from ACC-I and ACC-II steers. There were no differences in LD sensory-panel flavor, myofibrillar tenderness or overall tenderness scores among slaughter groups. The ACC-III LD steaks tended (P=.07) to have lower WBS values than the other slaughter groups, which contradicts their higher detectable connective-tissue scores. Perhaps more severe carcass-chilling conditions would have resulted in some cold toughening of LD muscle from ACC-I, and maybe ACC-II, cattle. Yet Dikeman et al. (1985) reported that ACC LD steaks were more tender and flavorful than CONV LD steaks. From that study and ours, it appears that ACC production, in which steers are fed a high-energy diet beginning after weaning and slaughtered at a Good-grade end point (ACC-II), results in LD palatability at least equal to LD palatability of CONV-produced steers. Marchello et al. (1979) found no differences in flavor or tenderness by an untrained taste panel, when comparing meat from ACC and CONV cattle fed three levels of concentrate and slaughtered at 1.02 cm fat thickness.

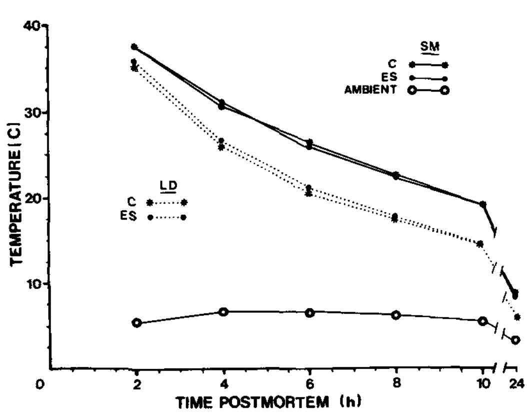

Figure 2. Postmortem temperature declines for control (C) and electrically stimulated (ES) longissimus (LD) and semimembranosus (SM) muscles.

TABLE 5. EFFECTS OF ELECTRICAL STIMULATION ON CARCASS QUALITY TRAITS

Trait	Overall	
	C	ES
24-h marbling[a]	7.6	8.3
48-h marbling[a]	8.0	8.5
Quality grade[b]	8.5	8.9
Lean maturity[c]	40.6	36.5
Lean color[d]	2.4	2.1
Lean firmness[d]	2.3[e]	2.7[f]
Lean texture[d]	3.2	3.0

[a]7 = Sl⁻, 8 = Sl°, 9 = Sl⁺.

[b]8 = G⁻, 9 = G⁺, 10 = Ch⁻.

[c]Percentage within A maturity.

[d]1 = very light cherry red, very firm or very fine to 7 = black, extremely soft or very coarse.

[e,f]Means in the same row with different superscripts differ (P<.05).

All sensory-panel scores (except flavor) for the SM muscle from CONV steers were lower (P<.05) than those for ACC steers. In addition, WBS values were highest (P<.05) for steaks from CONV steers. It is possible that the generally slower chill rate of the heavier, fatter CONV carcasses under our mild chilling conditions may have resulted in some protein denaturation, which might have had a detrimental affect on SM palatability. However, these results are consistent with those of Dikeman et al. (1985) in that ACC production resulted in SM palatability superior to that of CONV production, and faster chilling rates were used in their study. Therefore, chilling rate may not be the major consideration. From our

TABLE 6 LEAST-SQUARES MEANS FOR PRODUCTION-SYSTEM AND ELECTRICAL-STIMULATION EFFECTS ON LONGISSIMUS AND SEMIMEMBRANOSUS SENSORY-PANEL SCORES AND WARNER-BRATZLER SHEAR VALUES

Trait	Accelerated			Conventional	Carcass treatment	
	I	II	III		C	ES
Longissimus						
WBS, kg	3.4	3.5	3.0	3.3	3.0	3.0
Flavor[a]	6.2	6.3	6.2	6.5	6.3	6.3
Juiciness[a]	5.9[b]	6.2[bc]	6.0[b]	6.4[c]	6.0	6.2
Myofibrillar tenderness[a]	6.5	6.5	6.3	6.5	6.8[c]	6.4[b]
Connective tissue amount[a]	7.0[c]	7.0[c]	6.6[b]	6.7[b]	7.0	6.8
Overall tenderness[a]	6.5	6.6	6.3	6.4	6.9[c]	6.4[b]
Semimembranosus						
WBS, kg	4.8[bc]	4.4[b]	4.6[b]	5.2[c]	4.6	4.7
Flavor[a]	6.0	6.2	6.0	6.0	6.1	6.0
Juiciness[a]	5.8[bc]	5.9[c]	6.1[c]	5.6[b]	5.9	5.8
Myofibrillar tenderness[a]	5.7[c]	5.8[cd]	6.0[d]	5.4[b]	5.9	5.7
Connective tissue amount[a]	5.5[c]	5.6[c]	5.5[c]	5.1[b]	5.4	5.4
Overall tenderness[a]	5.6[c]	5.6[c]	5.7[c]	5.1[b]	5.6	5.5

[a]1 = extremely bland, dry, tough or abundant; 8 = extremely intense, juicy, tender or none.

[b,c,d]Means in the same row that do not have a common superscript differ (P<.05).

results, the CONV production system for large-type steers appears less desirable from the standpoint of meat palatability than the ACC system.

The SM overall tenderness scores tended to be more highly related to SM connective tissue (r =. 84) than to SM myofibrillar tenderness (r = .60) or SM juiciness (r = .53). However, for the LD, overall tenderness was more highly related to myofibrillar tenderness (r = .94) than to LD connective tissue (r = .52).

ES Effects on Palatability Traits. The only significant effects of ES on palatability were to decrease (P<.05) LD myofibrillar and overall tenderness scores (table 6). In contrast, Grusby et al. (1973), Davey et al. (1976), Bouton et al. (1978), Savell et al. (1978a,b, 1979), McKeith et al. (1981) and Martin et al. (1984) reported increased tenderness from ES for LD muscles and either a positive or no effect on LD juiciness scores. Other researchers (Jeremiah and Martin, 1980; Marsh, 1983) found little or no benefit from ES on LD muscle. Takahashi et al. (1984) found that low-frequency ES, coupled with mild or delayed chilling, resulted in toughening of loin steaks. Low-frequency ES did not cause the tissue rupture that is caused by high-frequency ES, and the chilling treatment prevented cold shortening (two of the three theories for why ES causes tenderization). They concluded that rapid glycolysis alone actually decreases tenderness. Our conditions certainly were not conducive to cold shortening and may have caused some protein denaturation. Therefore, rapid glycolysis coupled with mild chilling conditions may have had a detrimental effect on palatability. We did not examine tissue rupture; if it occurred at all, it was not extensive enough to improve tenderness.

Savell et al. (1977), Davey et al. (1976) and Gilbert and Davey (1976) all reported no taste-panel tenderness differences between ES and C SM muscle, which agrees with our results.

Because there were no significant interactions for slaughter group × carcass treatment combinations for any of the sensory-panel or WBS traits, we conclude that ES effects were consistent across slaughter groups in having no effect (P>.05) on LD WBS force, and sensory-panel flavor, juiciness and detectable connective tissue. Furthermore, ES consistently decreased LD myofibrillar and overall tenderness across all slaughter groups. We realize, however, that more rapid chilling may have caused different effects of ES on palatability.

From results obtained from our ES procedure and mild chilling conditions, it is clear that ES did not improve meat palatability, but actually had a detrimental effect. We anticipated that ES might be more beneficial to the lighter weight, trimmer carcasses of ACC-I because Savell et al. (1978a) reported a greater benefit from ES on trim carcasses compared with fat ones.

Axe et al. (1983) evaluated the effects of ES combined with hot boning on the same cattle utilized in our study. They found that ES did eliminate the toughening effect caused by hot boning without ES.

For large-type steers like those in our experiment, rapid growth and efficient feed utilization can be maintained for up to 178 d (ACC-II) on a high-energy diet beginning shortly after weaning. This is equivalent to an average slaughter age of about 14 mo.

Dressing percentage increased (P<.05) 3.0% from ACC-I to ACC-II slaughter groups, yet fatness was increasing at a relatively slow rate during this time (31.5 vs 32.4% EE in 9-10-11th rib tissue, respectively). Consequently, the rapid increase in proportion of carcass weight and the slow rate of increase in fat deposition indicates an advantage for ACC-II steers over ACC-I steers. On the other hand, industry price differentials for Good and Choice carcasses may suggest that an end point equivalent to our ACC-III cattle (56% Choice and average yield grade of 2.9) may be more profitable.

The low dressing percentage, greater time and feed requirements, and somewhat fatter carcasses from CONV steers suggest that the CONV production system may not be practical or economical for large-type steers. The CONV steers did, however, attain 61% Choice carcasses. The LD steaks from either ACC-I or ACC-II steers were at least equal in palatability to ACC-III and CONV steaks, except that ACC-III LD steaks tended (P=.07) to have lower WBS values and CONV LD steaks had higher (P<.05) juiciness scores than ACC-I steaks. The SM steaks from ACC-I and ACC-II steers were superior to CONV steaks and equal to ACC-III steaks, except for myofibrillar tenderness. Severe chilling conditions may have resulted in decreased palatability for our lighter weight, trimmer carcasses such as those in ACC-I. With our experimental conditions, there was almost no advantage in feeding steers beyond 139 d and definitely no advantage in feeding beyond

178 d. For muscles relatively high in connective tissue, CONV production may be detrimental to meat palatability for large-type steers.

With our mild carcass-chilling conditions, ES had a slight detrimental effect on meat palatability. Therefore, our results indicate that ES may not be beneficial under all slaughter and chilling conditions.

Except for the problem of a low percentage of Choice carcasses, feeding moderately large-type steers a high-energy diet after weaning and slaughtering them by 14 mo of age appears to optimize production and processing efficiency and meat palatability.

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