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Palatability of Beef from Bulls Administered Exogenous Hormones

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ABSTRACT

One-hundred and forty four weanling bulls of Angus (A, n = *48), Simmental* × *Hereford (SH,* n = *48) and Simmental (S,* n = *48) breeding were either castrated, left intact, left intact and implanted with Ralgro or left intact and implanted with Synovex S. Cattle were slaughtered after either 190, 246 or 315 days of high-energy feeding, and the right side of each carcass was electrically stimulated. Sensory analysis was conducted on* longissimus dorsi *steaks after 5 days aging and Warner-Bratzler shear force (WBS) was measured after 5, 10 and 15 days aging. Steers had lower (*P < 0·05*) WBS and more desirable sensory panel scores for juiciness, ease of fragmentation, amount of connective tissue and overall tenderness than all intact treatments. The implanting of weanling bulls with synthetic steroid hormone compounds did not make a practical improvement in beef tenderness.*

INTRODUCTION

Many researchers have suggested the use of intact males in red meat production to meet consumer's demand for a leaner product. Meat

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toughness or variability in tenderness has been a major limitation to the use of intact bulls for lean beef production (Seideman *et al.*, 1982). Johnson *et al.* (1984) concluded that administration of Ralgro, Synovex or Compudose to young bulls during a 118-day finishing period had no effect on palatability traits. However, it should be noted that the bulls used in the study of Johnson *et al.* (1984) were approximately one year of age at the time treatment began, and, thus, the onset of puberty had already occurred. Greathouse *et al.* (1983) reported that testicle size, aggressive male behavior and development of secondary sex characteristics was decreased when bulls were implanted with Ralgro at a young age (preweaning) and continued at approximately 106-day intervals until slaughter. In the same study, use of Ralgro improved taste panel tenderness ratings and decreased Warner-Bratzler shear force (WBS) values. Therefore, the objective of this study was to examine the changes in palatability of meat from intact males caused by implanting weanling intact bulls with synthetic steroid compounds.

MATERIALS AND METHODS

The types of animals, treatment, dietary regimens, and the carcass traits of the experimental material, and the procedure for electrical stimulation, have been described in the previous paper (Shackelford *et al.*, 1992). Carcasses were chilled for 24 h at −1·5°C at which time 2·54-cm steaks were removed from the first through fifth lumbar vertebra of each side of the carcasses for determination of sensory panel attributes at 5 days postmortem and WBS at 5, 10 and 15 days postmortem. Steaks were vacuum-packaged and aged at 2°C until the appropriate day postmortem and then frozen at −30°C. Sensory and WBS analysis of all slaughter groups were conducted simultaneously so that inferences could be made as to the effect of increased time on feed.

Steaks were tempered at 4°C for 24 h then broiled to an internal temperature of 40°C, turned, and broiled to a final internal temperature of 70°C on electric broilers (Farberware Open-hearth Broilers, Model 450N, Kidde, Inc., Bronx, NY). Internal temperature was monitored by an iron/constantan thermocouple probe attached to a potentiometer (Honeywell Potentiometer Multipoint Recorder, Model 112). Steaks for sensory panel analysis were wrapped in aluminium foil and held in an oven (South Bend Convection Oven, V2511) at 77°C for not more than 45 min. Samples were trimmed and sectioned into 1 cm^3 portions before being served to an eight-member trained sensory panel (Cross *et al.*, 1978). Panelists scored the steaks on a one- to eight-point rating scale for juiciness, ease of fragmentation, amount of connective tissue, overall tenderness,

flavor intensity and off-flavor (eight = extremely juicy, easy, little, tender, intense or nondetectable and one = extremely dry, hard, abundant, tough, bland or strong). Steaks for WBS determination were broiled as before and then tempered at 4°C for 24 h before the removal of six 1·3 cm diameter cores, from each steak, parallel to the longitudinal orientation of the muscle fibers. Cores were sheared with a WBS device attached to an Universal Testing Machine (Model 1122, Instron Universal Testing Machine, Instron Corp., Canton, MA 02021, USA) equipped with a Microcon computer. The crosshead speed was 5 cm/min and the fail criterion was 75%.

At 24 h postmortem, one 2·54 cm thick steak was removed from the *longissimus dorsi* (LD) opposite the last thoracic vertebra of the left side of a subsample ($n = 48$) of the carcasses and frozen at −30°C for subsequent determination of collagen content. Total and percent soluble collagen fractions were separated according to Hill (1966). Hydroxyproline content was determined according to Bergman & Loxley (1963) and hydroxyproline content of the soluble and insoluble portions were multiplied by factors of 6·75 and 6·25, respectively, as described by Cross *et al.* (1973).

For collagen traits, analysis of variance (Steel & Torrie, 1980) was conducted according to SAS (1985) using the following model (T = treatment; S = slaughter endpoint; B = breed):

$$Y_{ijkl} = \mu + T_i + S_j + (TS)_{ij} + B_k + (TB)_{ik} + (SB)_{jk} + \text{Animals}\,(T_i S_j B_k)$$

Animals $(T_i S_j B_k)$ served as the error term for T_i, S_j, $(TS)_{ij}$, B_k, $(TB)_{ik}$ and $(SB)_{jk}$. For sensory panel traits, electrical stimulation (E) also was included in the designs as a split-plot:

$$\begin{aligned} Y_{ijkl} = {} & \mu + T_i + S_j + (TS)_{ij} + B_k + (TB)_{ik} + (SB)_{jk} \\ & + \text{Animals}\,(T_i S_j B_k) + E_l + (TE)_{il} + (SE)_{jl} \\ & + (BE)_{kl} + (TSBE)_{ijkl} \end{aligned}$$

$TSBE_{ijkl}$ served as the error term for E_l, $(TE)_{il}$, $(SE)_{jl}$ and $(BE)_{kl}$. For WBS data, length of postmortem storage (D) also was included in the designs as a split-split-plot:

$$\begin{aligned} Y_{ijkl} = {} & \mu + T_i + S_j + (TS)_{ij} + B_k + (TB)_{ik} + (SB)_{jk} \\ & + \text{Animals}\,(T_i S_j B_k) + E_l + (TE)_{il} + (SE)_{jl} + (BE)_{kl} \\ & + (TSBE)_{ijkl} + D_m + (TD)_{im} + (SD)_{jm} + (BD)_{km} \\ & + (ED)_{LD} + (TSBED)_{ijkLD} \end{aligned}$$

$(TSBED)_{ijklm}$ served as the error term for D_m, $(TD)_{im}$, $(SD)_{jm}$, $(BD)_{km}$ and $(ED)_{lm}$. When the main effect or interaction was significant, mean separation was accomplished using least-squares procedures (Montgomery, 1984). The predetermined level of significance was $P < 0{\cdot}05$.

RESULTS AND DISCUSSION

Steers had lower ($P < 0.05$) WBS values and scored higher for juiciness, ease of fragmentation, amount of connective tissue and overall tenderness than all intact treatments (Table 1). These findings are similar to those reported in the reviews of Field (1971) and Seideman *et al.* (1982). Ralgro-implanted bulls had higher WBS than the nonimplanted bulls, while bulls implanted with Synovex S scored lower for overall tenderness. Flavor intensity scores were not affected by treatment while off-flavor scores were lower for the implanted treatments. The present study failed to show any improvement in bull beef palatability due to synthetic steroid hormone implantation. Johnson *et al.* (1984) showed no difference in juiciness, muscle fiber tenderness, amount of connective tissue, overall tenderness, off-flavor, overall palatability and shear force between nonimplanted intact bulls and bulls implanted with Ralgro, Synovex or Compudose. In that study, bulls were first implanted at approximately one year of age while in the present study, cattle were implanted at weaning. Greathouse *et al.* (1983) reported that implantation of bulls with Ralgro improved flavor and connective tissue amount scores. In the same study, no differences were seen in myofibrillar tenderness, overall tenderness and WBS between nonimplanted and

TABLE 1
Effect of Treatment on Palatability Traits

	Steer	*Intact*	*Intact Ralgro*	*Intact Synovex S*	*SEM*
Warner-Bratzler shear force (kg)	4.3^{d}	4.9^{c}	5.1^{b}	5.1^{bc}	0.1
Sensory trait[a]					
Juiciness	5.5^{b}	5.2^{c}	5.2^{c}	5.2^{c}	0.05
Ease of fragmentation	5.3^{b}	5.0^{c}	4.9^{c}	4.9^{c}	0.05
Amount of connective tissue	5.3^{b}	5.0^{c}	4.8^{c}	4.9^{c}	0.05
Overall tenderness	5.4^{b}	5.1^{c}	5.0^{cd}	5.0^{d}	0.05
Flavor intensity	5.8	5.8	5.8	5.8	0.02
Off-flavor	2.5^{b}	2.5^{b}	2.4^{c}	2.4^{c}	0.02
Collagen characteristics					
Total collagen (mg/g)	2.4	2.7	2.2	2.7	0.2
Percent soluble collagen	22.0	19.8	20.8	18.1	2.3

[a] Scored on a one- to eight-point scale (8 = extremely juicy, easy, little, tender, intense or nondetectable and 1 = extremely dry, hard, abundant, tough, bland or strong).
[bcd] Means in the same row with superscripts that do not have a common superscript letter differ ($P < 0.05$).

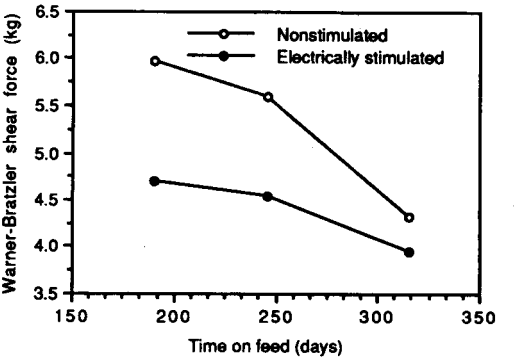

Fig. 1. The interaction of slaughter endpoint and electrical stimulation on Warner-Bratzler shear force.

implanted bulls fed to a heavy weight (499 kg) endpoint, but implanted bulls resulted in more tender meat when fed to a light weight (454 kg) endpoint.

Electrical stimulation and slaughter endpoint interacted to affect WBS values (Fig. 1). The amount of improvement in WBS values due to electrical stimulation decreased as the WBS values of the nonstimulated sides decreased with additional feeding. Also, postmortem aging period and slaughter endpoint interacted to affect WBS values (Fig. 2). The response to aging was greatest for the first slaughter group and least for the last slaughter group (Fig. 2). Ease of fragmentation, amount of connective tissue, overall tenderness and off-flavor scores did not differ between 190 and 246 days on feed but were higher after 315 days on feed (Table 2). Juiciness and flavor intensity were not affected by slaughter endpoint.

Across breed types, WBS was greatest for S (Simmental), intermediate for SH (Simmental-Hereford) and lowest for A (Angus) (Table 3). Juiciness, flavor intensity and off-flavor were not affected by breed type. In a similar

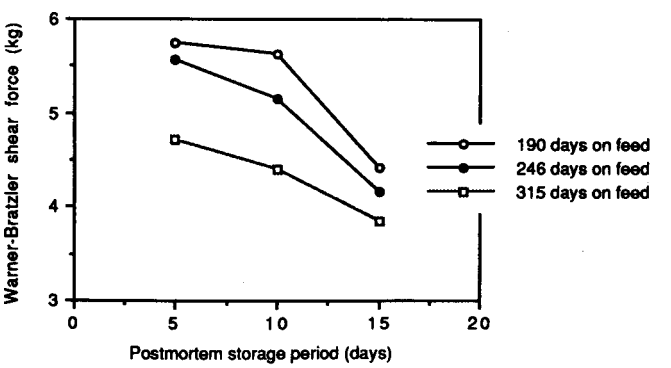

Fig. 2. The interaction of postmortem storage period and slaughter endpoint on Warner-Bratzler shear force.

TABLE 2
Effect of Slaughter Endpoint on Palatability Traits

	Days on Feed			SEM
	190	*246*	*315*	
Warner-Bratzler shear force (kg)	5·3[b]	5·1[c]	4·1[d]	0·1
Sensory trait[a]				
Juiciness	5·3	5·2	5·3	0·04
Ease of fragmentation	5·0[c]	4·9[c]	5·2[b]	0·04
Amount of connective tissue	4·9[c]	4·9[c]	5·2[b]	0·05
Overall tenderness	5·1[c]	5·0[c]	5·3[b]	0·05
Flavor intensity	5·8	5·8	5·8	0·02
Off-flavor	2·4[c]	2·4[c]	2·5[b]	0·02
Collagen characteristics				
Total collagen	2·7	2·7	2·2	0·2
Percent soluble collagen	20·3	19·0	21·2	1·9

[a] Scored on a one- to eight-point scale (8 = extremely juicy, easy, little, tender, intense or nondetectable and 1 = extremely dry, hard, abundant, tough, bland or strong).
[bc] Means in the same row with superscripts that do not have a common superscript letter differ ($P < 0·05$).

study, Johnson *et al.* (1984) reported no differences between breed types (Hereford, Hereford-Angus and Charolais cross) for juiciness, muscle fiber tenderness, amount of connective tissue, overall tenderness, off-flavor and WBS. Electrical stimulation eliminated the variation in amount of connective tissue (Fig. 3), ease of fragmentation (Fig. 4) and overall tenderness (Fig. 5) scores among breeds. For the nonstimulated sides, A, SH and S scored highest, intermediate and lowest ($P < 0·05$), respectively, for

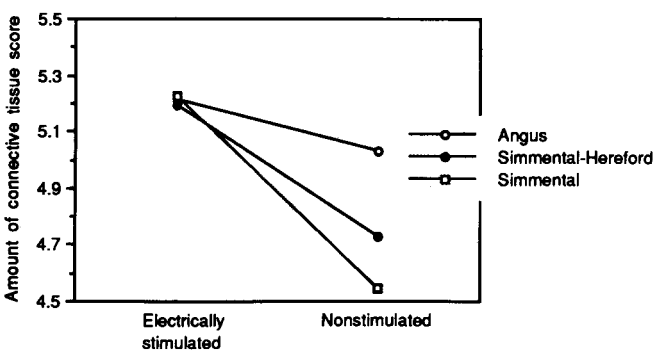

Fig. 3. The interaction of electrical stimulation and breed type on amount of connective tissue scores.

TABLE 3
Effect of Breed on Palatability Traits

	Angus	*Simmental-Hereford*	*Simmental*	*SEM*
Warner-Bratzler shear force (kg)	4·2[d]	5·1[c]	5·3[b]	0·1
Sensory trait[a]				
Juiciness	5·3	5·3	5·3	0·04
Flavor intensity	5·8	5·8	5·8	0·02
Off-flavor	2·4	2·4	2·4	0·02
Collagen characteristics				
Total collagen	3·1[b]	2·1[c]	2·3[c]	0·2
Percent soluble collagen	18·2	22·3	20·0	1·9

[a] Scored on a one- to eight-point scale (8 = extremely juicy, intense or nondetectable and 1 = extremely dry, bland or strong). None of these traits was affected by breed ($P < 0·05$).

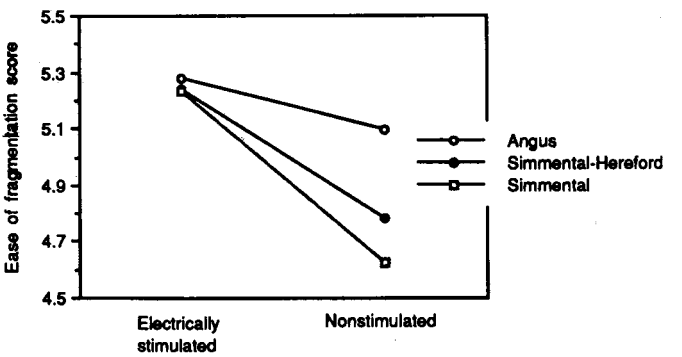

Fig. 4. The interaction of electrical stimulation and breed type on ease of fragmentation scores.

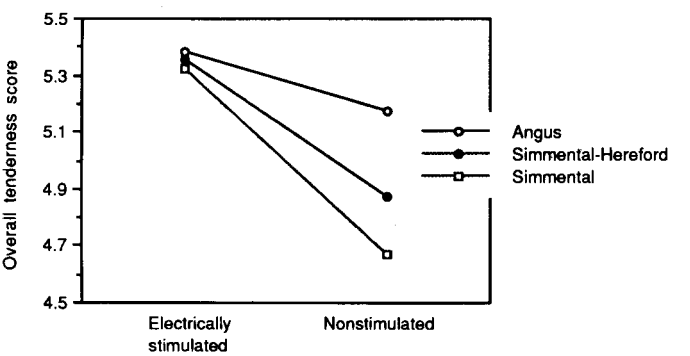

Fig. 5. The interaction of electrical stimulation and breed type on overall tenderness scores.

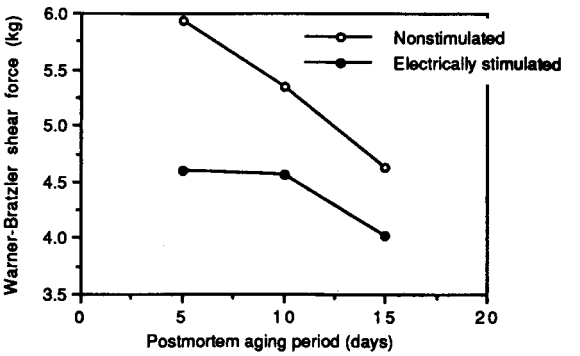

Fig. 6. The interaction of postmortem storage period and electrical stimulation on Warner-Bratzler shear force.

amount of connective tissue, ease of fragmentation and overall tenderness; however, for the stimulated sides, there were no differences between breeds for each trait. Electrical stimulation improved off-flavor scores (data not in tabular form). However, it is doubtful that the change in mean off-flavor scores (2·5 versus 2·4 on an 8-point scale) is of practical importance.

Electrical stimulation and postmortem aging period interacted to affect WBS values (Fig. 6). The amount of improvement in WBS values due to aging was much lower for the electrically stimulated sides.

Steers, bulls, bulls implanted with Ralgro and bulls implanted with Synovex S did not differ in collagen solubility or total collagen content (Table 1). Moreover, collagen traits did not change with added time on high energy feed (Table 2). Total collagen was higher in A than S and SH (Table 3). Based on the WBS data, one would have expected collagen content to be greatest in S and least in A. Simple correlations of percentage soluble collagen and total collagen with WBS at 5, 10 and 15 days postmortem were not significant ($P > 0{\cdot}05$).

IMPLICATIONS

Bull beef palatability was not improved by the implanting of weanling bulls with Ralgro or Synovex S. This suggested that synthetic steroid hormones may need to be administered to bulls at a very young age (prepuberal) in order to prevent the development of tough, unpalatable beef. Further research must be conducted to determine methods by which the biochemical changes that occur in the muscle of bulls during puberty can be manipulated.

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REFERENCES

Bergman, I. & Loxley, R. (1963). *Anal. Chem.*, **35**, 1961.
Cross, H. R., Carpenter, Z. L. & Smith, G. C. (1973). *J. Food Sci.*, **38**, 998.
Cross, H. R., Moen, R. & Stanfield, M. S. (1978). *Food Technol.*, **36**, 48.
Field, R. A. (1971). *J. Anim. Sci.*, **32**, 849.
Greathouse, J. R., Hunt, M. C., Dikeman, M. E., Corah, L. R., Kastner, C. L. & Kropf, D. H. (1983). *J. Anim. Sci.*, **57**, 355.
Hill, F. (1966). *J. Food Sci.*, **31**, 161.
Johnson, D. D. (1992). *Meat Sci.*, **32**, 387.
& Martin, J. J. (1984). *J. Anim. Sci.*, **58**, 920.
Montgomery, D. C. (1984). *Design and Analysis of Experiments, 2nd edn.* John Wiley Book Co., New York, USA.
SAS (1985). *SAS User's Guide: Statistics.* Statistical Analysis System Institute, Inc., Cary, NC, USA.
Shackelford, S. D., Crouse, J. D., Savell, J. W., Cross, H. R., Schanbacher, B. D. & Johnson, D. D. (1992). *Meat Sci.*, **32**, 387.
Seideman, S. C., Cross, H. R., Oltjen, R. R. & Schanbacher, B. D. (1982). *J. Anim. Sci.*, **55**, 826.
Steel, R. G. D. & Torrie, J. H. (1980). *Principles and procedures of Statistics: A Biometrical Approach, 2nd edn.* McGraw-Hill Book Co., New York, USA.