Implant strategies during feeding: Impact on carcass grades and consumer acceptability[1,2]

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ABSTRACT: Anabolic growth promotants influence beef grade factors and Warner-Bratzler shear force of steaks. No study has assessed the consumer acceptability of beef derived from implanted cattle. This study determined beef carcass grades and consumer acceptability for cooked beef from unimplanted (control) cattle and from cattle implanted with one of seven different implant strategies (initial implant/implant at 59 d = Encore & Component T-S/no implant, Ralgro/Synovex Plus, Ralgro/Revalor-S, Revalor-S/Revalor-S, Revalor-S/no implant, no implant/Synovex Plus, and Synovex Plus/no implant). British crossbred steers (n = 448) were allocated randomly into one of eight pens for each of the control and seven treatment groups. Carcass quality and yield grade (n = 403) and Warner-Bratzler shear force (n = 298) data were collected by trained personnel. Twenty steaks per control or treatment group were selected randomly for use in consumer sensory evaluation. Steaks were evaluated by consumers for overall like, tenderness like, tenderness level, flavor like, flavor intensity, and juiciness level using 9-point, end-anchored hedonic scales. Control carcasses had smaller ($P < .05$) longissimus muscle areas than carcasses in all treatment groups except those receiving Encore & Component T S/no implant, Ralgro/Synovex Plus, or Revalor S/no implant. Control carcasses had higher ($P < .05$) marbling scores than carcasses in all treatment groups except those receiving Ralgro/Revalor-S or Encore & Component T-S/no implant. Steaks from control steers had lower ($P < .05$) Warner-Bratzler shear force values than steaks from steers given Revalor-S/no implant. Consumer ratings for tenderness like and tenderness level were influenced ($P < .05$) by implant strategy. Effects of implant strategy on overall like, flavor like, and flavor intensity approached significance ($P = .07$ to .09). Consumers rated steaks from unimplanted steers as more tender (tenderness level; $P < .05$) than steaks from all treatment groups except that involving Encore & Component T-S/no implant. Consumers rated steaks from unimplanted steers as more desirable ($P < .05$) for tenderness like than steaks from all treatments except those involving Encore & Component T-S/no implant or Revalor-S/no implant. Although use of implants in this study resulted in heavier hot carcass weights and larger ribeyes, some of the implant strategies reduced consumer preference of tenderness of steaks.

Key Words: Beef, Carcass Quality, Growth Promoters, Palatability

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Introduction

The U.S. beef cattle industry has adopted the use of growth-promoting implants as a routine management practice because of market incentives to increase growth rates and reduce costs of live weight gain. Over the past two decades, new anabolic compounds have been developed and strategies for implanting feedlot cattle have been refined. Approved anabolic implants are characterized as being either estrogenic, androgenic, or both estrogenic and androgenic in effect (Morgan, 1997). The approval of the use of trenbolone acetate in the late 1980s and the subsequent approval of implants containing both estrogenic compounds and trenbolone acetate have increased the number of implanting strategies that can be used to improve feedlot cattle performance.

Belk and Cross (1988) and Morgan (1997) concluded that use of anabolic growth promotants can compromise beef carcass quality grades due to reduced marbling scores and increased incidence of dark cutters. More importantly, some implanting strategies have reduced eating satisfaction of the subsequent beef product, spe-

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cifically by increasing the incidence of tough beef as determined by Warner-Bratzler shear force (Samber et al., 1996; Foutz et al., 1997; Morgan, 1997). This study evaluated the impact of seven implant strategies, compared to an unimplanted control, on beef carcass quality and yield grade characteristics and consumer acceptability of cooked beef from small to medium-framed, British crossbred steers.

Materials and Methods

Cattle Background. Small- to medium-framed steers (n = 448) from a three-breed (Red Angus, Hereford, and Shorthorn) cross were used for the study. Cattle were weaned on a ranch in Wyoming and were placed on a silage-based grower diet at the ranch. Calves were not implanted before being placed on the diet.

Cattle were placed on feed in February 1998 at a commercial research feedyard and were fed identical high-concentrate diets throughout the study (Table 1). Upon placement in the feedyard, and at the time of processing, steers were allocated randomly to one of eight feeding pens (serving as a block) and implant strategy (control or treatment) was randomly allocated to pens of steers.

Implant strategies were as follows: 1 (**CON**) = no implant/no implant; 2 (**EC-N**) = Encore & Component T-S/no implant; 3 (**R-SP**) = Ralgro/Synovex Plus; 4 (**R-RS**) = Ralgro/Revalor-S; 5 (**RS-RS**) = Revalor-S/Revalor-S; 6 (**RS-N**) = Revalor-S/no implant; 7 (**N-SP**) = no implant/Synovex Plus; 8 (**SP-N**) = Synovex Plus/no implant. Table 2 describes the composition and manufacturer of each implant.

Implant Protocol. Implants were administered to cattle in the seven treatment groups at 0 d on feed (if appropriate for that treatment) followed by another implant at 59 d on feed (if appropriate for that treatment) in mid-April. Cattle in the control group and those not receiving an implant at that time were handled in the same manner as those receiving implants to ensure consistency in handling between control and treatment groups. Cattle determined to have a "defective" implant at the time of re-implantation were removed from the study. The steers were fed 140 or 141 d (depending on the date of slaughter) and slaughtered in two equally balanced groups; three pens per implant strategy group were slaughtered on July 7, 1998, and five pens per implant strategy group were slaughtered on July 8, 1998.

Carcass Evaluation. Cattle were transported from the feedlot in Wellington, Colorado to a commercial beef packing plant in Fort Morgan, Colorado and slaughtered using conventional procedures. Animal/carcass identification was maintained throughout the slaughter process.

On the slaughter floor in the packing plant, the ears of each steer were evaluated by licensed veterinarians to determine whether the implants had been applied correctly, were not crushed, and were still present. When an implant was found to have been applied incorrectly, or if it was crushed or missing altogether (at re-implantation or at slaughter), data from that carcass and strip loin were not considered further in the analysis.

Following a 36-h carcass chilling period, Colorado State University personnel obtained carcass grade data. Data for fat thickness, adjusted fat thickness, longissimus muscle area, percentage kidney, pelvic, and heart fat, lean maturity, skeletal maturity, overall carcass maturity, and marbling score were obtained for each carcass. Yield grades were calculated using regression equations and quality grades were determined after evaluation by combining the overall maturity and the marbling scores.

Strip Loin Selection and Collection. From the original seven steers per feeding pen per implant strategy group, carcasses from cattle with missing, crushed, or improperly applied implants and those that had been extensively trimmed (for bruises or zero tolerance [removal of visible contamination]) were excluded. From

Table 1. Composition of diets

Diet (time fed) and ingredient	Ingredient, % as-fed diet	Diet CP, %	Diet NEp/Cwt[a]
1 (7 d)			
Flaked corn	35.50	12.6	45.9
Corn silage	49.00	—	—
Ground alfalfa hay	7.75	—	—
Liquid supplement	7.75	4.4	1.7
2 (12 d)			
Flaked corn	58.50	13.8	52.9
Corn silage	26.50	—	—
Ground alfalfa hay	4.75	—	—
Liquid supplement	10.25	5.8	2.3
3 (17 wk)			
Flaked corn	70.50	14.1	56.8
Corn silage	18.00	—	—
Liquid supplement	11.50	6.5	2.6

[a]NEp/Cwt = net energy of production per hundred weight.

Table 2. Implant composition and manufacturer

Implant	Composition	Manufacturer
Encore & Component T-S	43.9 mg of estradiol 200 mg trenbolone acetate	Vet Life, Winterset, IA
Ralgro	36.0 mg zeranol	Schering Plough, Madison, NJ
Synovex Plus	28 mg estradiol benzoate 200 mg trenbolone acetate	Fort Dodge Labs, Neshanic, NJ
Revalor-S	24 mg estradiol benzoate 120 mg trenbolone acetate	Hoechst Roussel Vet, Somerville, NJ

the remaining carcasses, the first five eligible carcasses on the chain were tagged for strip loin collection. The carcasses were fabricated and designated strip loins (NAMP #180) (NAMP, 1997) were collected and shipped to Colorado State University (**CSU**) where steaks were cut for Warner-Bratzler shear force at CSU and consumer sensory panel evaluation at CSU and Texas A& M University.

Warner-Bratzler Shear Force. Each strip loin (n = 298) was aged for 14 d at 5°C. Following aging, strip loins were cut into 2.54-cm-thick steaks for Warner-Bratzler shear force analysis and for consumer sensory panel analysis. The first steak from the anterior end of each strip loin was identified and vacuum-packaged separately for Warner-Bratzler shear force analysis. The next four steaks were identified and packaged, two steaks each in two vacuum packages, for consumer sensory panel analysis.

Following aging, steaks were frozen at –29°C for approximately 30 d before Warner-Bratzler shear force analysis or for approximately 150 d before consumer sensory panel evaluation. For Warner-Bratzler shear force determination, steaks were tempered at approximately 0°C for 24 h and cooked on a Hobart Char Broiler (model CB 51, Hobart Corp., Troy, OH) at a surface temperature of approximately 260°C. Each steak was turned at 4, 8, 12, and, if necessary, 16 min until reaching an internal temperature of 71°C (monitored using a type T thermocouple; Omega Engineering, Stamford, CT). At the designated internal temperature, each steak was removed from the broiler and cooled to room temperature (approximately 22°C) and 6 to 10 1.25-cm cores were removed from each steak parallel to the muscle fiber orientation using a mechanical coring device. A single peak shear force measurement was obtained for each core using a Warner-Bratzler shear force machine; mean peak shear force value for each steak was determined by averaging values for the 6 to 10 cores removed from each steak.

Consumer Panelist Selection. A telemarketing firm (Client Insight, Fort Collins, CO) with expertise in conducting telephone surveys and consumer recruitment recruited consumers in College Station, Texas (n = 150) and Fort Collins, Colorado (n = 150) using randomly generated telephone listings. Consumers were contacted by telephone and prescreened to ensure that they were at least 18 yr of age. Approximately equal numbers of males and females were recruited to be representative of age and income based on demographic information obtained from the Chamber of Commerce in each city. Consumers selected based on the above criteria, and that were willing to participate, were assigned to 1 of 10 consumer sessions conducted in each city in January and February 1999. Due to an expected percentage of non-respondents, 150 consumers were recruited in order to ensure that each consumer session included 10 to 12 participants. Each steak sample for a given session was evaluated by a minimum of four and a maximum of six consumers.

Sample Preparation. Twenty steaks per control or treatment group were selected randomly using a random number generator for sensory evaluation. Two steaks per carcass were shipped to College Station, Texas via a refrigerated freight contractor and two steaks per carcass were stored in Fort Collins, Colorado. Steaks from each selected strip loin were evaluated by consumers in both Texas and in Colorado.

Frozen, vacuum-packaged steaks were placed in a 4°C cooler for 24 h, and after thawing steaks were unpackaged and weighed. A type T thermocouple (Omega Engineering) was placed in the geometric center of each steak and the internal temperature for each steak was monitored during cooking using a microprocessor thermometer (Omega model HH21, Omega Engineering). Steaks were cooked on an open-hearth Farberware grill (Model R4550, Farberware Products, Nashville, TN) and cooking time was recorded. Steaks for the consumer panel sessions were cooked on a Farberware Grill instead of the Char Broiler to allow for use of the same preparation equipment in each city. Steaks were cooked to an internal temperature of 35°C, at which time they were turned and cooked to a final internal temperature of 71°C. After cooking, steaks were weighed and cooking loss was recorded as the percentage of weight lost between the precooked and cooked steak weights.

Steaks were cut into approximately 1.27- × 1.27- × 2.54-cm cubes, covered, and placed in a warming oven (49°C) until they were served to consumers. Although steaks were cooked immediately before consumer evaluation, samples were held in the warming oven for up to 60 min due to the need for consumers to evaluate samples from the eight control or treatment groups in a random order over the course of the panel session. Sessions lasted approximately 60 min.

Consumer Sensory Evaluation. Consumers were seated in a random, circular order in a room containing standard fluorescent lighting. At the beginning of each session, consumers were presented with an Informed Consent Form, which they were asked to read and sign as an indication of their willingness to participate. The procedures for this project were approved by the Texas A&M University Use of Humans as Subjects in Research Committee. Consumers then were asked to answer 11 demographic and meat consumption questions that appeared on the ballot. Instructions regarding the structure of the ballot and sampling procedures for steak samples were provided verbally to the consumers in each session. Consumers were provided double-distilled, deionized water and unsalted crackers. Consumers were instructed to take a bite of cracker followed by a drink of water between samples to cleanse their palates. Each consumer evaluated one steak sample from each of the eight control or treatment groups during each session. The order of steaks provided to each consumer was randomized (across control and treatment groups) and five to six consumers evaluated each steak sample from each subprimal strip loin in each city (location).

Consumers rated each sample for overall like/dislike, flavor like/dislike, intensity of flavor, tenderness like/dislike, level of tenderness, and level of juiciness using 9-point, end-anchored hedonic or intensity scales, where 1 = like extremely, like extremely, none or extremely bland, like extremely, extremely tender, and extremely juicy, respectively, and 9 = dislike extremely, dislike extremely, extremely intense, dislike extremely, extremely tough, and extremely dry, respectively.

Statistical Analysis. For carcass traits and Warner-Bratzler shear force values, individual steers/carcasses were considered to be the experimental unit. The mixed model analysis included treatment as a fixed effect and pen within treatment as a random block effect. The pen within treatment random effect was only significant for hot carcass weight, adjusted fat thickness, longissimus muscle area, percentage kidney, pelvic, and heart fat, and skeletal maturity. Because pen within treatment effects (random block effects) were not significant for the other dependent variables, the General Linear Models procedure of SAS (1996) was used to evaluate those response variables using treatment as a fixed effect. Analysis of variance (ANOVA) was used to ascertain whether responses differed by control or treatment group. When treatment effects were significant ($P < .05$), least squares means were reported and separated using a pairwise *t*-test procedure of SAS (1996). The distributions of quality and yield grades, as well as the Warner-Bratzler shear force (**WBS**) values, were compared using the chi-square option of the frequency procedure of SAS (1996). If the overall chi-square value was significant, Fisher's Exact Test (SAS, 1996) was used to separate the percentages of USDA Prime plus USDA Choice, USDA Yield Grade 1 plus USDA Yield Grade 2, and the percentage of WBS values over 3.9 kg.

Consumer sensory panel data were analyzed using the Mixed Models procedures of SAS (1996). Analysis of variance was used to ascertain whether responses differed by control or treatment group. Treatment was included in the model as a fixed effect and panelist within city by session was included as a random effect. When treatment effects were significant ($P < .05$), least squares means were reported and separated using the pairwise *t*-test procedure of SAS (1996). Simple regression coefficients were calculated, based on sample means calculated from the six panelist evaluations in each city, using correlation procedures of SAS (1996).

Results and Discussion

Carcass Evaluation and Warner-Bratzler Shear Force. Ears of all cattle were palpated at reimplantation and at slaughter by licensed veterinarians. Frequency of implant defects ranged from 2 (in the R-SP treatment group) to 10 (in the EC-N treatment group). Overall, 37 of the original 448 steers (8.3%) were removed due to improper implant application or implant damage before further selection or analysis was conducted.

The pen within treatment effect was significant for hot carcass weight, adjusted fat thickness, longissimus muscle area, and skeletal maturity ($P < .05$). Using the appropriate ANOVA model, least squares means for beef carcass quality and yield factors are presented in Table 3. All groups receiving implant(s), except for the EC-N treatment, had higher ($P < .05$) hot carcass weights than did the unimplanted cattle. Control carcasses had smaller longissimus muscle areas ($P < .05$) than carcasses from cattle in all treatment groups except those in the EC-N, R-SP, and RS-N groups. Steers in the RS-RS, R-RS, N-SP, and SP-N treatment groups had carcasses with significantly larger longissimus muscle areas than steer carcasses from the control group. Herschler et al. (1995) and Foutz et al. (1997) also reported that carcasses from steers implanted with a combination of estrogen benzoate and trenbolone acetate resulted in higher hot carcass weights and larger longissimus muscle areas than carcasses from unimplanted steers.

There was no difference ($P > .05$) in adjusted fat thickness among carcasses from the eight implant strategy groups. Previous studies have shown little or no effect of implant treatment on external fat thickness (Gerken et al., 1995; Samber et al., 1996; Foutz et al., 1997). Carcasses from steers in all treatments, except those involving EC-N and SP-N, had lower percentages ($P < .05$) of kidney, pelvic, and heart fat than carcasses from steers in the control group. Data reported by Bartle et al. (1992) and Duckett et al. (1996) also reported lower percentages of kidney, pelvic, and heart fat in cattle implanted with combination implants.

Whereas differences occurred among carcasses in treatment groups in several of the factors used to compute USDA yield grades, only one significant difference

Table 3. Least squares means for carcass traits stratified by implant strategy

Implant strategy[a] (n)	HCW, kg[b]	AFT, cm[c]	LMA, cm^2 [d]	KPH, %[e]	YG[f]	Marbling scores[g]	Skeletal Maturity[h]	QG[i]
CON (54)	334.8^{l}	1.68	77.4^{m}	2.03^{k}	3.51^{kl}	524.3^{k}	65.6^{m}	523.8^{k}
EC-N (44)	352.8^{kl}	1.65	80.6^{klm}	1.86^{kl}	3.47^{kl}	511.6^{kl}	72.3^{kl}	515.1^{kl}
R-SP (53)	362.7^{k}	1.75	81.3^{klm}	1.79^{l}	3.59^{kl}	459.2^{lm}	74.2^{kl}	460.7^{m}
R-RS (48)	361.7^{k}	1.63	82.6^{kl}	1.67^{l}	3.40^{kl}	482.7^{klm}	74.4^{kl}	487.5^{klm}
RS-RS (48)	367.5^{k}	1.70	84.5^{k}	1.76^{l}	3.45^{kl}	449.6^{m}	77.3^{k}	454.1^{m}
RS-N (52)	361.3^{k}	1.80	80.0^{lm}	1.81^{l}	3.70^{k}	467.0^{lm}	75.0^{kl}	474.0^{klm}
N-SP (52)	359.1^{k}	1.63	82.6^{kl}	1.80^{l}	3.35^{l}	458.3^{m}	69.4^{lm}	463.4^{lm}
SP-N (52)	360.5^{k}	1.80	82.6^{kl}	1.85^{kl}	3.61^{kl}	470.4^{lm}	76.0^{k}	471.4^{lm}
SEM[j]	6.9	.08	1.3	.07	.09	13.2	2.1	13.7
Pen × trt *P*	.0001	.0138	.0002	.0001	NS	NS	.0001	NS

[1]Implant strategy: CON = no implant/no implant (control), EC-N = Encore & Component T-S/no implant, R-SP = Ralgro/Synovex Plus, R-RS = Ralgro/Revalor-S, RS-RS = Revalor-S/Revalor-S, RS-N = Revalor-S/no implant, N-SP = no implant/Synovex Plus, SP-N = Synovex Plus/no implant.
[b]HCW: Hot carcass weight.
[c]AFT: Adjusted fat thickness.
[d]LMA: Longissimus muscle area.
[e]KPH: Kidney, pelvic, and heart fat.
[f]YG = Yield grade, calculated using regression equations.
[g]Marbling scores are coded as 300 = slight, 400 = small, 500 = modest, and 600 = moderate.
[h]Skeletal maturity scores are coded as 1 to 100 = A maturity; 77.3 is A^{77}, etc.
[i]USDA quality grades (QG) are coded as 100 to 299 = Standard, 300 to 349 = low Select, 350 to 399 = high Select, 400 to 499 = low Choice, 500 to 599 = average Choice, and 600 to 699 = high Choice.
[j]SEM: Standard error of the mean (overall mean).
[k,l,m]Means in the same column with a common superscript letter are not different ($P > .05$).

in final yield grade was observed. Yield grades were not ultimately affected because the increase in yield grade due to hot carcass weight and kidney, pelvic, and heart fat and the reduction in yield grade due to increased longissimus muscle area offset one another in the calculations. Carcasses from steers treated with N-SP had a more desirable (lower) yield grade than carcasses from steers treated with RS-N.

Except for carcasses from steers treated with N-SP, skeletal maturity scores for implanted steer carcasses were more advanced ($P < .05$) than those from the unimplanted steer carcasses. Foutz et al. (1997) reported advanced skeletal maturity scores for steers implanted with combined estradiol benzoate and trenbolone acetate implants compared to unimplanted steers carcasses. In this study, whereas carcasses in treatment subclasses differed in skeletal maturity, there were no differences among treatments in lean maturity scores of carcasses. These data support Foutz et al. (1997), who reported that combined estradiol benzoate and trenbolone acetate implants caused more advanced skeletal maturity but did not affect lean maturity scores of carcasses.

Whereas Herschler et al. (1995) and Scanga et al. (1998) have reported darker longissimus muscle color or greater incidence of dark cutters for implanted vs control cattle, no dark cutting carcasses were observed in this study.

Except for carcasses from steers treated with R-RS or EC-N, control carcasses had higher ($P < .05$) marbling scores than carcasses from steers treated with implants. Except for carcasses from steers receiving R-RS or EC-N, control carcasses had higher ($P < .05$) USDA quality grades than carcasses from implant-treated steers. The percentage of carcasses grading USDA Prime or Choice ranged from 94.4% for control steers to 66.7% for steers from the RS-RS treatment (Table 4). Except for carcasses from steers implanted with EC-N or R-RS, control steers produced higher ($P < .05$) percentages of Prime plus Choice carcasses than did treated steers.

Table 4. Distribution of quality grades by implant strategy

	Implant strategy group[a]							
Item	CON	EC-N	R-SP	R-RS	RS-RS	RS-N	N-SP	SP-N
Quality grade, % Prime plus Choice	94.4^{b}	93.2^{bc}	77.4^{d}	81.3^{bcd}	66.7^{d}	76.9^{d}	78.9^{cd}	75.0^{d}
Yield grade, % Y1 plus Y2	18.5^{b}	15.9^{b}	9.4^{b}	16.7^{b}	12.5^{b}	3.9^{b}	19.6^{b}	13.7^{b}

[a]Implant strategy: CON = no implant/no implant (control), EC-N = Encore & Component T-S/no implant, R-SP = Ralgro/Synovex Plus, R-RS = Ralgro/Revalor-S, RS-RS = Revalor-S/Revalor-S, RS-N = Revalor-S/no implant, N-SP = no implant/Synovex Plus, SP-N = Synovex Plus/no implant.
[b,c,d]Means in the same row and for the same trait with a common superscript letter are not different ($P > .05$).

Table 5. Least squares means and frequency distribution of Warner-Bratzler shear force values (kg) stratified by implant strategy group (n = 298)

Implant strategy	WBS value, kg	SEM	No. of animals < 3.9 kg (%)	No. of animals ≥ 3.9 kg (%)
No implant/no implant	2.97[b]	.65	33 (91.7)	3 (8.3)
Encore & Component T-S/no implant	3.18[ab]	.48	36 (92.3)	3 (7.7)
Ralgro/Synovex Plus	3.41[ab]	.58	30 (78.9)	8 (21.1)
Ralgro/Revalor-S	3.31[ab]	.62	28 (73.7)	10 (26.3)
Revalor-S/Revalor-S	3.28[ab]	.54	31 (86.1)	5 (13.9)
Revalor-S/no implant	3.51[a]	.60	25 (69.4)	11 (30.6)
No implant/Synovex Plus	3.42[ab]	.67	26 (70.3)	11 (29.7)
Synovex Plus/no implant	3.29[ab]	.51	31 (83.8)	6 (16.2)

[a,b]Means in the same column with a common superscript letter are not different ($P > .05$).

The percentage of carcasses grading Yield Grade 1 or 2 ranged from 18.5% for control steers to 3.9% for steers from the RS-N treatment (Table 4). The percentages of carcasses that were Yield Grade 1 or 2 did not differ ($P > .05$) among the eight implant strategy groups.

Warner-Bratzler shear force was determined for 298 samples due to the loss of 22 strip loins during fabrication in the packing plant (identification tags were lost or removed from the sample strip loins during the cutting process). Steaks from carcasses of steers implanted with RS-N were tougher ($P < .05$) than steaks from carcasses from control steers (Table 5); no other treatment WBS force value differed ($P > .05$) from that of the control group. Gerken et al. (1995) reported that androgenic and combination implants had no effect on beef tenderness of strip loin steaks. Additionally, Huck et al. (1991) and Belk and Savell (1992) reported that use of combined trenbolone acetate and estradiol implants did not affect beef tenderness, whereas Foutz et al. (1989) reported that steers implanted twice with trenbolone acetate had a greater likelihood of resulting in tough steaks than did steers implanted with a single trenbolone acetate implant or two estradiol implants.

Shackelford et al. (1991) identified a shear force value of 3.9 kg as a threshold value for consumer desirability of steaks. Of the loin steaks from carcasses of steers receiving implants (Table 5), those from the RS-N treatment group were most often "tough" (30.6% had a shear force value > 3.9 kg). Steaks from unimplanted steers were least often "tough" (8.3% had a shear force value > 3.9 kg), but none of these percentages differed statistically ($P > .05$).

Consumer Sensory Panels. Frequency distributions for each of the consumer demographic attributes are reported as a percentage of the total distribution (Table 6). Consumer age was slightly skewed to the younger categories; however, evaluations were collected for consumers in every age category. Of the incomes reported, the highest percentage of consumers had a yearly income of < $20,000, most likely because 17.1% of the consumers defined themselves as students. Distributions were similar among the remaining income categories for consumer incomes that were recorded. A very high percentage of consumers were white. The ethnic background distribution was not necessarily representative of the ethnic background of each of the communities in which panels were conducted but most likely reflected willingness to participate.

Consumer ratings for tenderness like/dislike, tenderness level, cooking time, and cooking weight loss were influenced ($P < .05$) by implant strategy (Table 7). Steaks from cattle in the control group had a higher ($P <$

Table 6. Frequency distribution of consumer demographic information

Category	%
Age level, yr	
< 20	7.9
20–29	34.3
30–39	15.3
40–49	13.9
50–59	13.0
60 or >	15.7
Annual household income level	
< $20,000	34.9
$20–29,000	13.2
$30–39,000	11.3
$40–49,000	7.5
$50–59,000	12.3
$60,000 or >	20.8
Household size	
1	19.5
2	38.6
3	13.0
4	17.7
5	6.5
6	4.7
Working status	
Not employed	26.9
Part-time	19.9
Full-time	36.1
Student	17.1
Gender	
Male	49.5
Female	50.5
Ethnic background	
White	94.4
Black	1.4
Hispanic	2.8
American Indian	0
Asian/Pacific Islander	1.4

Table 7. Least squares means for consumer sensory responses by implant strategy group

Sensory attribute	*P*-value	SEM[b]	Implant strategy group[a] CON	EC-N	R-SP	R-RS	RS-RS	RS-N	N-SP	SP-N
Overall L/D[c]	.0935	2.0	4.25	4.47	4.61	4.71	4.61	4.42	4.69	4.73
Flavor L/D[d]	.0832	2.0	4.14	4.34	4.47	4.52	4.34	4.33	4.71	4.47
Flavor intensity[e]	.0729	2.0	5.23	4.97	4.95	4.83	5.10	5.20	4.80	5.14
Tenderness L/D[f]	.0388	2.1	3.94[j]	4.25[ij]	4.48[i]	4.42[i]	4.54[i]	4.27[ij]	4.48[i]	4.46[i]
Level of tenderness[g]	.0059	2.1	3.90[j]	4.25[ij]	4.50[i]	4.49[i]	4.53[i]	4.45[i]	4.48[i]	4.54[i]
Juiciness level[h]	.1616	2.2	4.87	5.06	5.01	5.27	5.26	4.94	5.28	5.21
Cooking time, min	.0009	5.2	25.4[jk]	25.0[k]	24.9[k]	26.4[i]	26.2[ij]	24.6[k]	25.4[jk]	25.2[k]
Cooking loss, %	.0001	23.6	55.2[ijk]	57.6[i]	52.2[kl]	59.4[i]	49.2[l]	52.3[kl]	53.3[jkl]	56.7[ij]

[a]Implant strategy: CON = no implant/no implant (control), EC-N = Encore & Component T-S/no implant, R-SP = Ralgro/Synovex Plus, R-RS = Ralgro/Revalor-S, RS-RS = Revalor-S/Revalor-S, RS-N = Revalor-S/no implant, N-SP = no implant/Synovex Plus, SP-N = Synovex Plus/no implant.
[b]SD: Sample standard deviation for the given trait.
[c]Overall like to dislike (L/D) rating by consumers, where 1 = like extremely and 9 = dislike extremely.
[d]Like to dislike rating of flavor by consumers, where 1 = like extremely and 9 = dislike extremely.
[e]Intensity of flavor rated by consumers, where 1 = none or extremely bland and 9 = extremely intense.
[f]Like to dislike rating of tenderness by consumers, where 1 = like extremely and 9 = dislike extremely.
[g]Level of tenderness rating by consumers, where 1 = extremely tender and 9 = extremely tough.
[h]Level of juiciness rating by consumers, where 1 = extremely juicy and 9 = extremely dry.
[i,j,k,l]Least squares means within a row with a common superscript letter are not different ($P > .05$).

.05) percentage of cooked steak weight loss than steaks from cattle treated with RS-RS. Cooking time to the 70°C end point for steaks from unimplanted steers was shorter ($P < .05$) than for steaks in the R-RS group.

Consumers rated steaks from unimplanted steers as more tender ($P < .05$) than steaks from six treatment groups; which excluded steaks from steers treated with EC-N. Steaks from the EC-N treatment group were similar in tenderness to steaks from the other treatments ($P > .05$) and tended to be rated tougher than steaks from unimplanted steers ($P = .05$). Consumers rated steaks from unimplanted steers as more desirable ($P < .05$) for tenderness like/dislike than steaks from five treatment groups (which excluded steaks from steers treated with EC-N and RS-N). Based on these results, use of R-SP, R-RS, RS-RS, N-SP, or SP-N treatment strategies for finishing steers results in decreased tenderness desirability (like/dislike) and tenderness rankings (level) in a population of loin steaks derived from small- to medium-framed cattle that were fed to an excessively high degree of finish.

Comparisons of sensory panel evaluations across implant strategy groups revealed that differences in overall like/dislike ($P = .09$), flavor like/dislike ($P = .08$), and flavor intensity ($P = .07$) approached statistical significance. Perhaps due to some consumers' generalization of a trait (tenderness like/dislike, flavor intensity, etc.) because of a favorable evaluation of the overall palatability (also known as the halo effect), consumers tended to rate steaks from unimplanted steers as more desirable in flavor than steaks from cattle treated with N-SP or R-RS, due, in part, to the lower tenderness

Table 8. Simple correlation coefficients between consumer sensory responses

Sensory attribute	Consumer sensory response: Flavor L/D[a]	Flavor intensity[b]	Tenderness L/D[c]	Tenderness level[d]	Juiciness level[e]	Cooking time, min	Cooking loss, %	WBS, kg
Overall L/D[f]	.86*	−.47*	.74*	.63*	.69*	.01	.05	.11
Flavor L/D		−.50*	.61*	.50*	.63*	.00	.02	.03
Flavor intensity			−.32*	−.27*	−.33*	.08	−.06	.00
Tenderness L/D				.92*	.79*	.08	.14	.34*
Tenderness level					.76*	.12	.15	.38*
Juiciness level						.11	.10	.13
Cooking time, min							.39*	.04
Cooking loss, %								.04

[a]Like to dislike (L/D) rating of flavor by consumers, where 1 = like extremely and 9 = dislike extremely.
[b]Intensity of flavor rated by consumers, where 1 = none or extremely bland and 9 = extremely intense.
[c]Like to dislike rating of tenderness by consumers, where 1 = like extremely and 9 = dislike extremely.
[d]Level of tenderness rating by consumers, where 1 = extremely tender and 9 = extremely tough.
[e]Level of juiciness rating by consumers, where 1 = extremely juicy and 9 = extremely dry.
[f]Overall like to dislike rating by consumers, where 1 = like extremely and 9 = dislike extremely.
*Simple correlation coefficients differ from zero ($P < .05$).

ratings for steaks from the implanted cattle. Consumers also tended to rate steaks from unimplanted steers as more desirable in overall like/dislike than steaks from cattle implanted with SP-N, R-RS, N-SP, RS-RS, or R-SP.

Simple correlation coefficients between consumer sensory responses are reported in Table 8. Overall like/dislike was moderately to highly, and positively, related to flavor like/dislike, tenderness level, and juiciness level. Therefore, consumers liked steaks that they rated as tender and juicy and for which they liked the flavor. As flavor intensity increased from bland to strong (more intense in flavor), consumer overall like/dislike ratings decreased. Cooking time and cooking loss were not related to any palatability attributes as evaluated by the untrained consumer panel. Flavor like/dislike was moderately and positively related to consumer like/dislike for tenderness, tenderness level, and juiciness level. When consumers liked the flavor, they tended to rate the steaks as tender and juicy; when consumers disliked the flavor of steaks, they tended to rate the steaks as tough and dry. Flavor like/dislike was negatively and moderately related to flavor intensity. When consumers rated steaks as being more intense in flavor, they also disliked the flavor.

Correlation coefficients (Table 8) indicated that the strongest relationship between sensory attributes was between ratings for tenderness like/dislike and tenderness level, which were highly and positively correlated. Consumers also rated juicy steaks as more tender than dry steaks. As cooking time increased, cooking loss tended to increase, but this relationship was not strong. Warner-Bratzler shear force values were moderately correlated to tenderness like/dislike and tenderness level ($r = .34$ and $.38$, respectively) as determined by the panelists. Correlation coefficients also indicated that there was a strong, positive relationship between the tenderness level, tenderness like/dislike, and overall like/dislike ratings.

Implications

The Beef Industry Long Range Task Force of the National Cattlemen's Beef Association documented "the opportunity to increase tenderness both pre- and post-harvest and through preparation" as one of the demand drivers for the beef industry. The fact that growth promotants increase the production efficiency of cattle is widely known. Based on the results of this study, growth promotants may be detrimental to the tenderness of the product. Producers must determine the potential impact of implants when used within their genetic base. The beef industry must determine the interaction of the impact of growth promotants on beef acceptability and the ability to increase tenderness using preslaughter practices.

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