

The Effect of Stage of Growth and Implant Exposure on Performance and Carcass Composition in Steers.

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Summary

Angus and Angus cross Limousin steers ($n = 182$; initial BW = 681 ± 61.2 lb) were used to evaluate the influence of an estradiol-trenbolone acetate implant (24mg/120mg) on production efficiency and carcass traits when administered at specific stages of growth. Treatments (TRT) were as follows: No Implant, control (NI), Early Implant, d 1, BW = 681 lb (EI); or Delayed Implant, d 57, BW = 845 lb (DI). Comparisons were also made between the NI and implanted treatments (I; EI + DI). Steers were procured at weaning and were backgrounded (47 d) prior to the initiation of the experiment. Initial predicted carcass composition was 14.9% protein, 13.3% fat, 54.6% moisture, and 17.2% bone. Days on feed was constant across TRT. After 56 d, ADG and gain efficiency (G/F) were improved ($P < 0.01$) by implants, (NI vs. EI; 3.70 vs 4.19 lb and 0.227 vs. 0.257). At d 57 predicted carcass composition was not different among treatments. From 57 to 112 d, DI caused higher ADG than NI or EI (NI 3.64, EI 3.46, and DI 3.92 lb; $P < 0.05$) and higher G/F (NI 0.155, EI 0.150, and DI 0.173; $P < 0.01$). Cumulative ADG (3.64 vs 3.81 lb; $P < 0.05$) and G/F (0.175 vs. 0.186; $P < 0.01$) were improved by implants for NI vs. I, respectively with no differences between treatments that involved implants. Cumulative DMI was similar for all TRT. Implants increased dressing percent (63.5 vs. 64.1%; $P < 0.05$), hot carcass weight (752 vs. 778 lb; $P < 0.01$), and LM area (11.9 vs 12.6 in²; $P < 0.010$) for NI vs. I, respectively. Ribfat and kidney, pelvic, and heart fat were unaffected by TRT. Treatment had no effect on the whole carcass proportions of fat, protein, or water. Implants advanced maturity scores (NI A⁵¹ vs. I A⁵⁹; $P < 0.01$). Marbling scores were reduced ($P < 0.05$) by EI but not by DI (NI Small⁶⁵, EI Small²⁰, DI Small³⁶). The percent intramuscular fat content

of the LM was reduced ($P < 0.10$) by EI and was unaffected by DI (NI 5.1, EI 4.0, DI 4.8%). Treatment affected ($P < 0.10$) the proportion of carcasses with marbling scores greater than Modest⁰ (NI 23.6, EI 7.8, DI 22.6%). The results of this study suggest that growth of intramuscular fat is sensitive to anabolic growth promotants administered during early periods of growth.

Introduction

Beef producers have used growth promoting implants for the past 40 yr to improve growth rate (30%) and feed efficiency (15%; Preston, 1999). Carcass leanness can be improved by up to 8% when compared to non-implanted controls at the same body weight. In 1991 the option of using a single implant that contained both an estrogen (estradiol; E₂) and an androgen (trenbolone acetate; TBA) was made available to beef producers. The combination of E₂ and TBA increased ADG and feed efficiency more than either substance alone (Preston, 1999). Research has shown that administration of a combination implant too close to harvest can reduce marbling scores (Kerth et al., 1996). Pritchard (2000) suggested that the reduction in quality grade may be from administering an improper implant strategy. Using implants that varied in their level of potency, Pritchard (2000) reported that carcasses developed marbling scores similar to non-implanted contemporaries if a lower potency implant was administered early in the finishing phase. The disparity between studies outcomes among researchers may lie in the timing as well as the potency of the implant. Understanding how implants affect marbling development would aid in the selection of more appropriate implant strategies. This study was conducted to quantify development of intramuscular fat growth relative to changes in body composition in steers fed high energy diets and implanted at two different points in the finishing phase growth curve.

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Materials and Methods

Animals. Angus and Angus x Limousin cross spring born steers (n = 186) were weaned and transported 340 miles to the South Dakota State University Nutrition Unit where they were individually tagged and processed in early November. Before initiating the study steers were backgrounded for 47 d at a targeted gain of 2.2 lb/d. Steers were ranked by weight and four outliers were removed. Fifteen steers that were closest to the mean weight of the group were selected and randomly assigned to one of three serial harvest treatments. Steers selected for serial harvest were fed in pens by treatment. To measure production variables the remaining 167 steers were randomly assigned to one of three treatments with seven replicates per treatment: No Implant, control (NI); Early Implant, E₂TBA (24mg/120mg) d 1, BW = 295 kg (EI), or Delayed Implant, E₂TBA (24mg/120mg) d 56, BW = 850 lb (DI). Each treatment-replicate was randomly distributed to one of 21 pens. The allotment system caused a similar distribution of body weight in each pen. Steers were fed in paved outdoor pens measuring 25 ft. x 25 ft. deep with a 25 ft. fence-line feed bunk. Each pen contained 7 or 8 steers. Steers were fed once daily in the afternoon and had continual access to water. A clean bunk management system was used with steers being brought up to ad libitum intakes within 14 d. The diet contained 74.9% ± 0.72 DM, 12.9% ± 0.09 CP, 6.1% ± 0.12 ADF, 13.7% ± 0.36 NDF, and 3.2% ± 0.08 ash. The estimated final diet energy density was 0.93 Mcal/lb NE_m and 0.61 Mcal/lb NE_G. Cattle were weighed on trial on December 21, 2000 at which time implants (Revalor-S, Intervet, Millsboro, DE) were administered to EI. Steers (n = 5) assigned to the initial harvest group were transported to the South Dakota State University Meat Lab and processed.

Three calves were removed from the study with their BW contribution to the pen mean deleted from the onset of the experiment. Care, handling, and sampling of animals used in this study were approved by the South Dakota State University Animal Care and Use Committee.

Steers were weighed every 28 d to monitor weight gain and to schedule appropriate implant and harvest dates. Steers averaged 849 lb on d 56. The following day (d 57) the DI treatment (Revalor-S, Intervet, Millsboro, DE) was administered. On d 58 steers assigned to serial

harvest from the EI treatment (n = 5) and non-implanted (n = 5) were transported to the SDSU Meat Lab for harvest. When steers reached 0.40 in. rib fat thickness, 30 steers (n = 10 from each treatment) were selected from near the mean body weight of each treatment for harvest over a 10 d period at the SDSU Meat Lab for compositional analysis. This began after 140 d on feed. Production data were calculated through 140 d to maintain the integrity of the experimental units (pens). The remaining steers (n = 134) were transported 120 mi to a commercial packing plant. Carcass data collected included hot carcass weight (**HCW**), LM area, s.c. rib fat thickness (**RF**), and percent kidney, pelvic and heart fat (**KPH**) depots (USDA, 1996). Estimates of bone maturity and marbling score (to the nearest 1/10) were recorded by trained university personnel or an official USDA Meat Grader. For steers harvested at the SDSU Meat Lab (n = 30) the KPH depot was removed by physical separation from each side of the chilled carcass and weighed to determine the actual percentage of carcass weight.

Carcass Composition. Following carcass data collection, the 9-10-11 rib section was removed from the right side of each carcass as outlined by Hankins and Howe (1946) on the steers (n = 30) harvested at the SDSU meat laboratory. Soft tissue was separated from bone and weights were obtained on each. The soft tissue was mixed and homogenized in a bowl chopper. Three samples weighing 100 g each were obtained and stored in polyethylene bags at -4° F. Chemical analysis of the soft tissue was conducted to determine water, ether extract (fat) and nitrogen content of the 9-10-11 rib section samples. Two 50-g samples were lyophilized to a constant weight (48 h). Water was calculated as the difference between fresh frozen and lyophilized sample weight. The lyophilized samples were then combined and immersed in liquid nitrogen and subsequently powdered with a Waring commercial blender. Samples (2g) were wrapped in ashless filter paper and extracted with petroleum ether in a side arm soxhlet to a constant weight (60 h) for ether extraction of lipid followed by drying at 140° F for 12 h. Crude fat was calculated as the difference between lyophilized and extracted sample weight. Crude protein was measured on extracted samples (1-1.5 g) by the macro-Kjeldahl method. Ash content was determined on 1 g lyophilized samples held at 1202° F for

12 h. Hankins and Howe (1946) equations for steers were used to predict composition of the carcass soft tissue from chemical composition of soft tissue from the 9-10-11 rib section and to predict the percentage of carcass fat, protein, moisture and ash. Empty body weight was calculated by the following equation of Old and Garrett (1987) where empty body weight = $[(1.316 * HCW) + 32.237]$.

Longissimus Sample. A 0.40 in. slice of the longissimus muscle was removed from the posterior portion of the 12th rib section from the right side of the carcass. All exterior fat and epimysial connective tissue was removed. The sample was then cut into 0.40 by 0.40 in. cubes and stored in Whirlpack plastic bags at -4° F. Samples were homogenized in liquid nitrogen as outlined previously. Ether extraction of the LM samples was performed in triplicate to quantify percent intramuscular fat (IMF) content of the LM at the 12th as outlined previously with the 9-10-11 rib sample.

Fractional growth. Fractional growth rate (FGR) was calculated as outlined by McCarthy et al. (1983) as the rate of carcass protein and fat gain divided by the total carcass protein or fat of the animal at the point of reference (d 0, 56, and 150). Growth rate is reported as a percentage increase in mass of growth per day. The equation to calculate FGR is as follows: $FGR = [(P_1 - P_0)/T] / [(P_1 + P_0)/2]$ where P_1 is the later measure of carcass tissue, P_0 is the earlier measure of carcass tissue, and T is the number of days between the two measurements.

Statistical Analyses. All performance variables were evaluated using General Linear Models procedure of SAS in a statistical model that included treatment. The experimental unit in these analyses was pen. Fishers LSD were used to separate treatment means. Analysis of carcass data was conducted in a similar fashion except that the individual steer was considered to be the experimental unit. Data were partitioned into comparisons for linear, quadratic, and cubic relationships. Regression equations were developed to quantify the change in carcass characteristics and composition throughout the feeding phase.

Results

Feedlot Performance. Feedlot performance data are summarized in Table 1. Implanting

increased BW and ADG, which are similar to responses reported elsewhere. The E₂TBA administered on d 0 (EI) increased ($P < 0.05$) body weight 3% and increased ($P < 0.05$) ADG 11% to d 56. During the period from d 57 to 112, implanted steers had 2% greater ($P < 0.05$) BW. The responses reported here are lower than previously reported by Pritchard (2000), who reported a 20% increase. Pritchard, 2000 reported that implanted steers maintained greater gains throughout the experiment than controls. In the present study, steers implanted on d 0 (EI) had increased ADG up to d 56, but d 57 to 112 and cumulative ADG (d 140) were not different from controls or DI. The lower than expected ADG response in this trial may be because implants did not stimulate ($P < 0.10$) DMI for the first 56 d, and cumulative DMI was not different ($P < 0.10$) between treatments (Table 1). The failure of the implant treatment to elicit a DMI response may have been caused by the high intake occurring during cold, winter weather. Gain efficiency (G:F) improved ($P < 0.05$) 13% for EI vs. NI the first 56 d period. Steers receiving an implant (EI or DI) in our study had 10.5% improvement ($P < 0.05$) in feed efficiency over controls at the conclusion of the trial.

Carcass Characteristics and Composition. Carcass measurements and carcass composition for the initial harvest group are shown in Table 2. Serial harvest at d 56 and the final harvest on d 150 are presented in Table 3. During the first 56 d HCW increased ($P < 0.05$) for EI vs. NI with no differences observed for other carcass traits. Implanting increased ($P < 0.05$) carcass weights by improved dressing percentage as well as by increasing body weight.

No differences were found among treatments for s.c RF at the 12th rib. Implanting increased LM area on d 150, while LM area measurements for EI steers at initial (d 0) and d-56 harvest were not different from controls. No difference was observed for KPH fat in steers harvested at d 56 or 150. Yield Grade was not different at d 56, with NI (3.3) and DI (3.0) being different ($P < 0.05$).

Early implant treatment decreased ($P < 0.05$) marbling scores compared to controls with no difference ($P > 0.10$) between NI and DI. Likewise, EI caused a lower ($P < 0.10$) percentage of carcasses with marbling scores of

greater than or equal to Modest⁰ (Table 4). An objective measurement of IMF content was conducted by quantifying the percent of IMF content of the longissimus dorsi at the 12th rib (n = 30). No differences were detected between treatments at d 56 or 150. However at d 150, EI steers had percent IMF content that was 20% lower than controls.

Initial carcass composition was derived from five steers selected to be a representative sample of steers in the experiment (Table 2). Whole carcass composition of serial harvest (d 56) and final harvest are presented in Table 5. Implanting with E₂TBA at d 0 or 56 had no effect on percent whole carcass protein, fat, moisture, or bone. Likewise, no differences were detected when proportions of protein and fat were evaluated on an EBW basis.

Fractional growth rates for protein, fat, and percent IMF are presented in Table 6. During the initial 56 d, steers receiving an implant on d 0 (EI) had greater FGR for protein compared to NI (NI 0.41 vs. EI 0.53; $P < 0.05$) with no difference in the FGR of carcass fat. Steers receiving an implant on d 57 had greater rates of protein accretion from d 57 to 150 compared to steers receiving an implant on d 0. Fractional accretion rate of percent IMF during the first 56 d was not different between NI and EI, but EI numerically reduced FGR by 43% compared to NI. Cumulative FGR for protein and fat were not different among treatments.

Empty body weight composition data in serially harvested steers are presented in Table 7. Implanting on d 0 increased ($P < 0.01$) EBW the first 56 d on feed compared to NI with no difference in the percent of protein or fat on an EBW basis. Likewise, EBW were increased ($P < 0.10$) for cattle receiving an implant (EI or DI) compared to NI at the conclusion of the study with no difference in the percentage of protein or fat between treatments. Regression equations (Table 8) were developed by regressing percent IMF against EBW (Figure 1). Steers receiving EI had lower ($P < 0.05$) rates of development of percent IMF compared to NI but were not different from DI.

To quantify differences in EBW at constant empty body fat (EBF; 28%), IMF content (4.0%), and marbling score (Small⁰), regression equations were developed for EBF, IMF, and marbling score as independent variables with

EBW as the dependant variable (Table 8). Empty body weights at a constant EBF, IMF, and marbling score are presented in Table 9. At 28% EBF steers receiving an implant (EI or DI) were 5.7% heavier on average than controls. Steers implanted on d 0 (EI) had 15% greater EBW at constant IMF content of 4% than NI. Likewise EI had 7.3% greater EBW than NI at a marbling score of Small⁰.

The Nutrient Requirements of Beef Cattle (NRC, 1996) adjust cattle so they are equivalent in body composition to the steers in the Garrett (1980) database. A standard reference weight at which cattle reach an expected final body fat was determined by averaging the percent body fat of cattle in studies where body composition was measured and many different body types and sizes were represented. Body fat percent was determined to be 27.8% at a Small degree of marbling with an EBW of 478 kg (1052 lb; NRC, 1996). In our study control steers reached 28% body fat at 546 kg (1201 lb) while EI and DI reached 28% body fat at 579 and 578 kg (1274 and 1272 lb), respectively (Table 9). Cattle in this study reached marbling scores of Small⁰ at lower percent body fat and had lower EBW at Small⁰ marbling than others. It has been well documented that growth promoting implants increase frame size. Implanted steers in our study reached 28% EBF at EBW that were 33 and 32 kg (72.6 and 70.4 lb) greater than controls for EI and DI, respectively. In our study NI and DI steers reached Small⁰ at similar weights while EI increased the live weight at which steers reached Small⁰ by 36 kg (79.2 lb) compared to controls (Table 9).

Implications

Results of this study showed that a combined implant of estradiol and trenbolone acetate can affect carcass traits and the growth rate of carcass protein and fat depending on the point of administration in the feeding phase of production. The greatest increases in protein gain occurred during the 56 d after steers received an implant. Intramuscular fat content of the longissimus dorsi was reduced and empty body weight at which steers reach Small amount of marbling increased for steers receiving an implant on d 1. Steers receiving a delayed implant can reach Small amounts of marbling at empty body weights similar to controls while attaining greater carcass weights at 28% empty body fat. These data would suggest that

implanting with a combined estradiol and trenbolone acetate implant early in the finishing phase could have adverse effects on the development of marbling

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Tables

Table 1. Effect of implant (Revalor-S) on feedlot performance

Item	No Implant	Early Implant	Delayed Implant	SEM
n	7	7	7	
Initial body wt, lb	679	681	681	2.2
Body wt, lb				
d 56	889 ^a	915 ^b	891 ^a	4.70
d 112	1,091 ^a	1,111 ^b	1,111 ^a	6.2
d 140	1,188 ^a	1,213 ^{ab}	1,215 ^b	8.6
Average daily gain, lb				
d 0 – 56	3.70 ^a	4.19 ^b	3.75 ^a	0.090
d 57 – 112	3.64 ^a	3.46 ^a	3.92 ^b	0.071
d 113 – 140	3.48	3.64	3.45	0.124
d 0 – 140	3.64 ^a	3.79 ^{ab}	3.81 ^b	0.057
Dry matter intake, lb				
d 0 - 56	16.29	16.34	16.34	0.027
d 57 - 112	23.39	22.97	22.75	0.227
d 113 - 140	24.60	23.77	23.88	0.348
d 0 – 140	21.25	20.88	20.77	0.154
Gain per lb DMI				
d 0 - 56	0.227 ^a	0.257 ^b	0.229 ^a	0.005
d 57 - 112	0.155 ^a	0.150 ^a	0.173 ^b	0.003
d 113 - 140	0.144 ^a	0.153 ^{ab}	0.157 ^b	0.005
d 0 - 140	0.175 ^a	0.185 ^b	0.187 ^b	0.002

^{a,b} Means without common superscripts differ ($P < 0.05$).

Table 2. Initial carcass traits and composition of steers (n = 5)

Item	Mean ± SE		
Carcass measurements			
Body wt, lb	648	±	6.6
Hot carcass wt, lb	379	±	12.8
Dressing percentage ^a	60.9	±	0.51
Ribfat, in	0.08	±	0.023
Ribeye area, in ²	9.5	±	2.43
Kidney, pelvic and heart fat, %	1.6	±	0.09
Maturity ^b	132	±	2.0
Marbling ^c	328	±	8.0
IMF, %	1.46	±	0.2
Predicted carcass composition ^d			
Protein, %	14.94	±	0.200
Fat, %	13.25	±	1.165
Moisture, %	54.61	±	0.935
Bone, %	17.20	±	0.197

^aDressing percent = HCW / (BW x 0.96) x 100.

^bA^o = 100.

^cSelect^o = 400; Small^o = 500.

^dPredicted values derived from Hankins and Howe (1946).

Table 3. Effect of implant on carcass characteristics^a

Item	Harvest groups ^b						
	d 56 harvest			Final harvest			
	NI ^c	EI ^c	SEM	NI ^c	EI ^c	DI ^c	SEM
<i>n</i>	5	5		55	51	53	
HCW, lb	500 ^d	536 ^e	7.1	752 ^d	776 ^e	780 ^e	8.6
Dressing, % ^g	58.9	60.8	0.74	63.5 ^d	64.1 ^e	64.3 ^e	0.24
Ribfat, in.	0.19	0.29	0.09	0.53	0.51	0.49	0.02
LM area, in ²	10.4	10.7	0.21	11.8 ^d	12.5 ^e	12.8 ^e	0.15
Kidney, pelvic, heart fat, %	2.1	2.2	0.14	2.2	2.2	2.1	0.11
USDA Yield Grade	2.0	2.2	0.20	3.3 ^d	3.2 ^{de}	3.0 ^e	0.08
Maturity ^h	140	138	1.4	151 ^d	161 ^e	156 ^f	1.8
Marbling ⁱ	448	396	22.0	565 ^d	520 ^e	536 ^{de}	11.3

^aLeast square means.

^bStatistical comparisons made within harvest group.

^cNI = No implant; EI = Early implant on d 0; DI = Delayed implant on d 56.

^{d,e,f}Means without common superscripts differ (*P* < 0.05).

^gDressing percent = HCW / (BW x 0.96) x 100.

^hA^o = 100.

ⁱSmall^o = 500; Modest^o = 600.

Table 4. Effect of implant on quality grade distribution^a

	No Implant	Early Implant	Delayed Implant
<i>n</i>	55	51	53
Premium choice, % ^b	23.6 ^c	7.8 ^d	22.6 ^c
Low choice, %	45.5	52.9	39.6
Select, %	30.9	37.3	37.8
Standard, %	0.0	2.0	0.0

^aChi square analysis.

^b Modest^o and higher.

^{c,d} Means without common superscripts differ ($P < 0.10$).

Table 5. Effect of implant on predicted whole carcass composition of serially slaughtered group^a

Item	Harvest groups ^b						
	d 56 harvest			Final harvest			
	NI ^c	EI ^c	SEM	NI ^c	EI ^c	DI ^c	SEM
<i>n</i>	5	5		10	10	10	
HCW, lb	500	536	6.6	752 ^d	769 ^e	767 ^{de}	6.4
Protein, % ^f	14.2	14.3	0.22	12.6	12.7	12.6	0.18
Fat, % ^f	19.1	17.6	0.76	28.8	28.4	28.1	0.93
Moisture, % ^f	50.3	51.8	0.63	44.8	45.6	44.9	0.68
Bone, % ^f	16.4	16.3	0.45	13.8	13.4	14.4	0.24
IMF content, % ^g	2.33	1.96	0.29	5.08	4.03	4.85	0.39

^a Least square means.

^b Statistical comparisons made within harvest group.

^c NI = No implant; EI = Early implant on d 0; DI = Delayed implant on d 57.

^{d,e} Means without common superscripts differ ($P < 0.05$).

^f Predicted values derived from Hankins and Howe (1946).

^g IMF content = percent intramuscular fat content of longissimus dorsi.

Table 6. Effect of implant on fractional accretion rate of carcass tissue

Item	No Implant	Early Implant	Delayed Implant	SEM
d 0 – 56 (n = 10)				
Protein	0.41 ^a	0.53 ^b		0.029
Fat	0.85	0.81		0.089
IMF	0.76	0.43		0.235
d 57 – 150 (n = 30)				
Protein	0.30 ^{ab}	0.26 ^a	0.32 ^b	0.017
Fat	0.82	0.84	0.82	0.031
IMF	0.76	0.70	0.70	0.082
Cumulative (n = 30) ^c				
Protein	0.34	0.35	0.35	0.010
Fat	0.76	0.77	0.76	0.015
IMF	0.73 ^d	0.60 ^e	0.69 ^{de}	0.044

^{a,b} Means without common superscripts differ ($P < 0.05$).

^c Average days on feed 150.

^{d,e} Means without common superscripts differ ($P < 0.10$).

Table 7. Effect of implant on predicted empty body composition^a

Item	Harvest groups ^b						
	d 56 Harvest			Final Harvest ^c			
	NI ^d	EI ^d	SEM	NI ^d	EI ^d	DI ^d	SEM
<i>n</i>	5	5		10	10	10	
Empty body wt, kg	332 ^e	351	4.1	480 ^g	491 ^h	491 ^h	3.8
Empty body fat, %	17.0	15.6	0.64	26.0	25.6	25.4	0.86
Empty body protein, %	11.8	11.8	0.14	10.5	10.6	10.5	0.14
Empty body fat, kg	56.5	55.0	2.86	124.9	125.8	124.4	4.43
Empty body protein, kg	39.0 ^g	41.5 ^h	0.62	50.5	51.8	51.7	0.79

^a Least square means.

^b Statistical comparisons made within harvest group.

^c Final harvest group averaged 150 d.

^d NI = No implant; EI = Early implant on d 0; DI = Delayed implant on d 56.

^{e,f} Means without common superscripts differ ($P < 0.01$).

^{g,h} Means without common superscripts differ ($P < 0.10$).

Table 8. Regression equations describing the linear relationship between empty body weight (x) and carcass components (y)^a

Item	Intercept	Linear Component	R ²	P-Value	SE ^b
Empty body fat, kg ^c					
No implant, NI	-84.09970	0.433646	0.958	0.0001	0.0214
Early implant, EI	-87.05683	0.430080	0.959	0.0070	0.0003
Delayed implant, DI	-76.242307	0.407297	0.934	0.0001	0.0255
Intramuscular fat content, %					
Non implant, NI	-3.02809	0.016797	0.786	0.0001	0.0021
Early implant, EI	-1.804642	0.011743	0.714	0.0001	0.0018
Delayed implant, DI	-2.471052	0.014870	0.672	0.0001	0.0025
Marbling					
No implant, NI	163.94213	0.73912	0.758	0.0001	0.0985
Early implant, EI	133.67879	0.74567	0.743	0.001	0.1033
Delayed implant, DI	155.95645	0.07755	0.643	0.0001	0.1348

^a Initial harvest, *n* = 5 hd; 56 d harvest *n* = 10 hd; End, *n* = 30 hd.

^b SE = Standard error.

^c Dependent variable empty body weight = (1.316 * HCW) + 32.287 (Old and Garrett, 1987).

Table 9. Effect of implant on empty body weight at constant empty body fat and percent intramuscular fat content reported in kg and (lb)^a

Item	Empty body weight, kg (lb) ^b		
	No Implant	Early Implant	Delayed Implant
28% Empty body fat ^c	546 (1204)	579 (1277)	597 (1316)
4% Intramuscular fat ^s	420 (926)	495 (1091)	435 (959)
Marbling score – Small ^{o e}	455 (1003)	491 (1083)	448 (988)

^a Values determined by regression analysis. Regression equations reported in Table 8.

^b Empty body wt, kg = (1.316 * HCW, kg) + 32.287; (Old and Garrett, 1987).

^c Determined using (empty body fat, kg/empty body wt, kg); Regression equation for empty body fat, kg reported in Table 8.

Figures

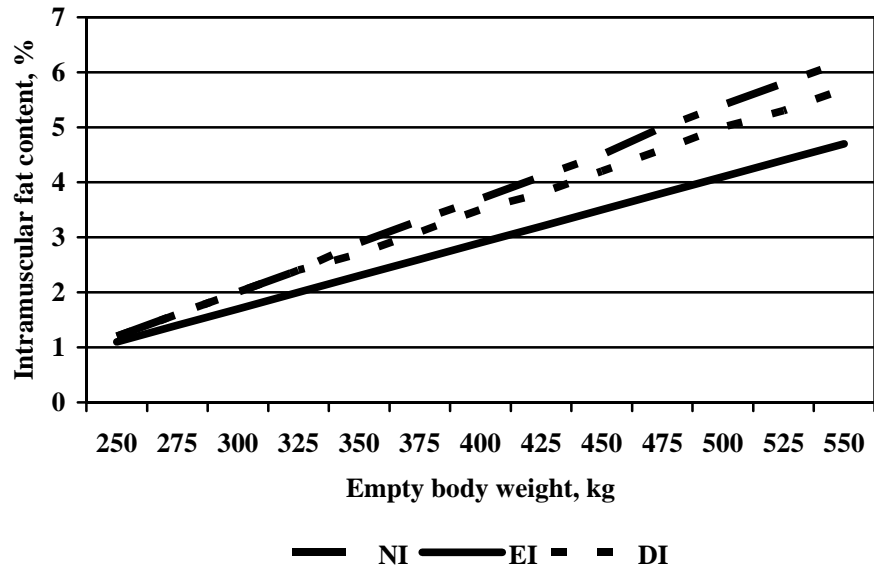


Figure 1. Effect of implant on rate of development of intramuscular fat content.
NI = No implant; EI = Early implant, d 0; DI = Delayed implant on d 57.