Growth Promotant Implants and Their Effects on Carcass Cutability and Quality

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Introduction

Growth promoting implants are used extensively in beef production to increase growth rate and profitability. In feedlot cattle, implants improve average daily gain (**ADG**) and feed efficiency by 15 to 25%. The resulting growth attributes seen in the feedlot phase carryover as an increase in saleable carcass. Increasing both gain and efficiency keep beef affordable to consumers.

To understand how to appropriately manage growth promotant implants in the production of beef one must understand the basic physiological effects implants have on animal growth. One of the basic effects of implants is to increase protein deposition or shifting the growth curve upwards. The net effect of this is a leaner animal at similar points in time when compared with nonimplanted animals.

Research has indicated that implants stimulate concomitant increases in absolute amounts of bone, muscle, and fat; however, proportions of these remain relatively similar to nonimplanted animals. This change in growth results in short-term increased ribeye area relative to marbling deposition, so if implanted and nonimplanted cattle are slaughtered at a common time, the implanted cattle will have a lower marbling score. However, serial slaughter studies involving implanted animals indicate that marbling scores will be similar to nonimplanted animals when cattle are harvested on a physiological endpoint (similar body composition) vs. a time constant endpoint. Therefore, it may be misleading to evaluate the results of implant studies utilizing time constant harvest trials. The inherent mode of action that implants have is on extending protein deposition of an implanted animal requiring they be fed to heavier weights to achieve similar body composition. Understanding the effect different implant strategies have on achieving a target carcass composition, coupled with knowledge of growth physiology and animal genetics, will allow us to use these tools in such a manner to fit a variety of feeding and marketing scenarios.

It is important to understand the effects growth promotant implants have on saleable yield of carcasses. Establishing this value is important to determine what increase in profitability can be realized throughout the beef chain. This added efficiency results in keeping beef competitive in the consumer's food basket as the consumer's food dollar becomes stretched in today's economy and the foreseeable future.

There has been concern in the beef industry that growth promotant implants might affect tenderness or other palatability factors. It is important that the complete body of data be evaluated to determine if any negative effects exist on beef palatability.

Understanding how different growth promotant technologies affect growth, live performance, carcass trait performance, cutability, tenderness, and sensory attributes will allow us to utilize them to increase profitability through the beef chain, which ultimately benefits the consumer.

Implants and Performance

Numerous studies have demonstrated that growth promotant implants increase ADG, carcass weight (**HCW**) and improve feed efficiency over nonimplanted cattle by 15 to 25% (Tables 1 and 2). These differences in performance are the result of implants shifting the composition of gain toward more protein deposition and decreasing fat at a particular time endpoint. Guiroy et al. (2002) evaluated 13 different trials representing 15 different implant treatments and concluded that implants improve efficiency of use of absorbed energy by 4.1 and 3.2% for steers and heifers after accounting for differences in body weight and composition of gain. This indicates that we can manage implant strategies to a target body composition and still improve efficiency of energy consumed.

Hutcheson et al. (2004) reported that steers implanted with Revlaor-S [120 mg of trenbolone acetate (**TBA**) and

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Table 1. Effect of different implant strategies on feedlot performance in steers.

Item	Control[a]	Synovex-S[a]	Control[b]	Revalor-S[b]	Revalor-200[b]
Dry matter intake, lb/hd/d			22.6[a]	24.2[b]	24.3[b]
ADG, lb/hd/d	3.06[a]	3.50[b]	3.35[a]	4.05[b]	4.14[b]
Feed efficiency	5.67[a]	5.31[b]	6.59[a]	5.84[b]	5.67[b]
HCW, lb	669[a]	722[b]	748[a]	804[b]	808[b]

[a]Herschler et al., 1995.

[b]Hutcheson and Nichols, 2000.

24 mg of estradiol 17-b (**E**)] and fed to a similar body composition as measured by quality grade distributions that exhibited an increase in final weight, carcass weight and no difference in feed efficiency and ADG when compared with steers implanted with Revalor-IS (80 mg of TBA and 16 mg of E). This study demonstrated that, depending on dosage level, different implants extend the protein deposition curve of growth requiring animals to reach heavier weights to achieve similar carcass compositions (Table 3).

Implant Effects on Finished Body Weight

Implanted cattle harvested at a constant time or weight endpoint have less empty body fat when compared with nonimplanted cattle. Johnson et al. (1996) reported that steers implanted with Revalor-S had increased bone and protein deposition when compared with nonimplanted animals. There was no effect of carcass fat accretion early in the feeding period, but at the end of the feeding period nonimplanted cattle had decreased fat accretion, whereas implanted cattle were continuing to deposit fat at a linear rate. This indicates that implanted cattle had not yet reached physiological maturity. At equal physiological maturity, carcass composition will be similar between implanted and nonimplanted cattle, but implanted cattle will have an increase in mature body size.

Growth promotant implants extend the length of time that cattle are in a phase of accelerated lean growth, causing the growth curve to shift upward. This allows animals to reach heavier weights efficiently before reaching the same body composition as nonimplanted cattle (Guiroy et al., 2002). This effect is dose dependent; as implant dose increases in both steers and heifers an incremental increase in body weight is required to reach similar body composition as nonimplanted cattle.

The net effect of implants on cattle growth is increasing protein deposition resulting in a leaner animal at similar points in time when compared with nonimplanted animals. We must begin to think about marketing cattle at similar body composition “fatness” due to the effect implants have on the growth curve. The effect of changing the growth curve has implications in feeding cattle to desirable carcass endpoints and should be considered when developing implant strategies for pens of cattle. Carcass endpoints are a function of the composition of protein and fat in the carcass. An understanding of these concepts will allow for management of different implant programs to fit desirable targets.

Feeding cattle to similar body compositions with different implant strategies can mitigate the negative effects implants have on marbling score and resulting quality grade distributions. Implants are an effective management tool to increase weights efficiently to achieve equal body composition.

Implant Effects on Yield Grade

Implanted cattle fed to a constant weight or days on feed will have reduced yield grade when compared with nonimplanted cattle. The mode of action of implants is to increase lean deposition in finishing cattle. When cattle are fed to a constant fat endpoint the differences in yield grade are minimized. This demonstrates that implanted cattle can be managed to achieve similar levels of fatness as measured by yield grade (Tables 4, 5, and 6).

Implant Effects on Quality Grade

Numerous trials indicate that at constant weight or time endpoints growth-promoting implants reduce marbling score and quality grade (Table 7), but in these same studies body composition at harvest was not equal between

Table 2. Effect of different implant strategies on feedlot performance in heifers.

Item	Control[a]	Finaplix-H +MGA[a]	Control[a]	Revalor-H[a]	Control[b]	Synovex-Plus[b]
Dry matter intake, lb/hd/d	19.6[a]	19.2[b]	19.6[a]	19.6[a]	16.4[a]	17.0[b]
ADG, lb/hd/d	3.18[a]	3.31[b]	3.17[a]	3.40[b]	2.73[a]	3.04[b]
Feed efficiency	6.19[a]	5.81[b]	6.19[a]	5.78[b]	5.99[a]	5.59[b]
HCW, lb	709[a]	720[b]	717[a]	737[b]	630[a]	653[b]

[a]Source: Intervet and Texas Tech University North American TBA Implant Database.

[b]Data from Herschler et al., 1995.

Table 3. Effects of days on feed and different implant strategies on feedlot performance.[a]

	Revalor-IS	Revalor-S
Item	123	145
Out weight, lb	1,322	1,395
Dry matter intake, lb/hd/d	21.2	21.3
ADG, lb/hd/d	3.85	3.85
Feed efficiency	5.51	5.57
Hot carcass weight, lb	847	902

[a]Hutcheson et al., 2004.

treatments. Therefore it may be misleading to conclude that growth-promoting implants decrease marbling score or quality grade without first accounting for potential differences in body composition. The mode of action of growth promotant implants is to extend the protein deposition curve. Numerous serial harvest studies indicate that feeding implanted cattle longer will mitigate the negative effects implants have on marbling at constant days on feed (Tables 8 to 11).

The depression in marbling score (quality grade) resulting from implanting and harvesting at constant days on feed can be reduced by feeding cattle to their proper finished weight (appropriate level of fatness), which is how cattle are typically marketed. Cattle not allowed to reach a certain level of fatness (body fat) will have a much more difficult time expressing their genetic propensity to marble (Perry and Fox, 1997). Preston et al. (1990) indicated that implanted steers should be harvested at 87 lb heavier body weight than nonimplanted steers to achieve the same marbling scores. Other factors that influence this finished weight are sex, genetics and previous nutritional program and these must be accounted for while developing appropriate marketing targets for pens of cattle. Johnson et al. (1995) reported that implanted cattle required an additional 35 to 44 d to reach a similar amount of marbling to nonimplanted controls.

Hutcheson et al. (2004) implanted cattle with either Revalor-IS or Revalor-S and harvested them at 123 and 145 d on feed. Results from this study demonstrated that Revalor-S cattle needed 22 more days to reach the same carcass composition in terms of quality grade distributions compared with Revalor-IS cattle harvested at the earlier date (Table 12). At the same time the cattle implanted with Revalor-S had an increase in carcass weight to achieve the same carcass composition. This demonstrates clearly that different implant strategies can affect the growth curve of animals and should be considered when developing implant strategies to market cattle.

Implant Effects on Carcass Cutability

Perry et al. (1991) demonstrated that a TBA and E combination implant in Holstein, Angus, or Angus × Simmental cross steers increased top butt yield but did not alter percentages of other cuts.

Al-Maamari et al. (1995) indicated that steers receiving TBA and E combination implants maintained the advantage in weight through to boxed beef yield regardless of trim level. Carcasses from implanted steers produced more total pounds of major and minor subprimals, lean trim total boxed beef, and bone at all trim levels. Implanted steers had greater yields of boneless closely trimmed boxed beef subprimals and a lower percentage of trimmable fat (Table 13).

Steers implanted with a combination of TBA and E increased subprimal and total side lean yields when compared with control and Synovex-S steers (Table 14). Total lean and primal lean was increased with implants while fat trim at 1.0″ or 0.5″ was decreased with implants with no change in bone expressed as a percentage of side weight (Foutz et al., 1997).

Hutcheson et al. (2007) evaluated cattle which had all received an initial implant (Revalor-IS) and which either received or did not receive a terminal implant (Revalor-S). Reimplanting with Revalor-S resulted in increased total saleable yield (70.1 vs. 72.6%), decreased fat trim (13.8 vs. 11.3%), and no change in bone as a percentage of the cold carcass weight (Table 15). Individual subprimals that were increased as a percentage of cold carcass weight with reimplanting were, shoulder clod, shoulder tender, chuck roll, mock tender, peeled knuckle, inside round, bottom round, eye of round, heel meat, striploin (0 × 1),

Table 4. Implants effects on yield grade at constant days on feed.[a]

Item	Control	Synovex-S	Revalor-S	Synovex-Plus
Avg. yield grade	3.2	3.1	2.8	2.8

[a]Adapted from Foutz et al., 1997.

Table 5. Implants effects on yield grade at constant weight.[a]

Item	Control	Synovex-Plus	Syn-S/Syn-Plus	Syn-Plus/Syn-Plus
Avg. yield grade	3.95	3.43	3.21	3.17

[a]Adapted from Johnson et al., 1995.

Table 6. Implants effects on yield grade at constant fat.[a]

Item	Control	Syn-Plus	Syn-S/Syn-Plus	Syn-Plus/Syn-Plus	Revalor-S
Avg. yield grade	3.45	3.38	3.34	3.37	—
Avg. yield grade	3.39	3.23	—	—	3.30

[a]Adapted from Johnson et al., 1995 and Hermesmeyer et al., 2000.

Table 7. Implant effects on quality grade (% Choice) in time-constant trials.[a]

Control	Revalor-S	Synovex-Plus	Revalor-200	Synovex-S
72	—	—	59	—
78	63	—	—	—
73	—	51	—	61

[a]Adapted from each product's Freedom of Information summary.

bottom sirloin flap, bottom sirloin tri-tip, peeled tender, flank steak, and 90/10 trim.

Carcass fabrication data on implants indicate that implants increase the percentage of saleable yield and decrease the amount of fat trim.

Implant Effects on Tenderness

Several reviews have been published regarding the effects of growth promotant implants on tenderness (Belk and Cross, 1988; Duckett et al., 1996; Nichols et al., 2002). These papers have evaluated tenderness by numerous methods [i.e., Warner Bratzler shear force (**WBSF**), slice shear force (**SSF**), and trained and consumer sensory panels].

Belk and Cross (1988) found that only 2 implant treatments from 1 of the 16 trials they evaluated negatively affected beef tenderness and concluded that tenderness is not significantly affected by growth promotant implants.

Duckett et al. (1996) conducted an extensive review of the literature on the effects of growth promotant implants in steers on meat tenderness. This review indicated that of the 29 trials evaluated only 5 comparisons between implanted and nonimplanted carcasses demonstrated an increase in WBSF due to implanting. It was concluded from the review that implants had no significant effect on beef tenderness (Table 16).

Nichols et al. (2002) conducted a review of the literature with primary focus on the effects of growth promotant implants containing TBA alone or in combination with E and their effects on tenderness of beef as measured by WBSF and taste panel evaluation of tenderness. Authors noted that in most trials there were no differences found as a result of implant strategy on the percentage of steaks that would be classified as tough (>4.54 kg). Ten of the 13 studies evaluated indicated no difference in sensory panel tenderness. Three of the 19 studies that evaluated WBSF showed an increase in shear force whereas 2 of the 19 showed implants improved tenderness. Furthermore,

Table 8. Implant effects on quality grade in heifers fed different days on feed.[a]

Days on feed	Control	Finaplix-H
108	90	56
131	88	83
143	77	75

[a]Nichols et al., 1996.

Table 9. Implant effects on marbling score in steers fed different days on feed.[a]

Days on feed	Control	Syn-S/Fin-S+Syn-S
60	400	360
90	440	410
120	440	420
150	400	380

[a]Nichols et al., 1991.

Table 10. Implant effects on quality grade in steers fed different days on feed.[a]

Days on feed	Control	Synovex-Plus	Syn-S/Syn-Plus
127	79	71	59
148	81	71	70
169	100	93	91

[a]Lee, 1994.

Table 11. Implant effects on quality grade in steers fed different days on feed.[a]

Days on feed	Control	Syn-Plus
169	57	27
207	61	55

[a]Stanton, 1995.

Table 12. Effects of Revalor-S and Revalor-IS at 2 different harvest dates on quality grade distribution.

Item	Revalor-IS 123	Revalor-S 123	Revalor-IS 145	Revalor-S 145
Choice or greater, %	53	48	57	56
Select, %	45	49	42	42
Standard, %	1.6	2.5	1.0	1.8

Table 13. Percentage yields for closely trimmed boxed beef, fat trim, and bone.[a]

Item	Control	Syn-Plus	Syn-S/Syn-Plus	Syn-Plus/Syn-Plus
Boxed beef yield	66.6	68.3	67.9	67.9
Fat trim	19.2	17.3	17.9	17.7
Bone	14.3	14.7	14.2	14.4

[a]Al-Maamari et al., 1995.

none of the studies included in this review demonstrated that all implant strategies in a particular experiment negatively affected shear force or sensory taste panel evaluations (Table 17).

It may be concluded from reviews of the literature by Nichols et al. (2002) and Duckett et al. (1996) that the trials summarized do not indicate a dose-dependent response as to the effects of increasing implant potency having a greater or more consistent effect on tenderness.

Overall conclusions from all these reviews evaluating currently available growth promoting implants demonstrated limited, if any, effects on beef tenderness measured by shear force or taste panels.

Platter et al. (2003) conducted a trial evaluating 11 different lifetime implant treatments and demonstrated that all implant strategies increased WBSF. However, in evaluating percentage of tender steaks (<4.5 kg) there was only one implant group, which contained the highest dosage of growth promotants, which demonstrated differences from control after 14 d of aging, whereas no implant groups were different from control at 21 d of aging. All implants demonstrated differences in tenderness, flavor and juiciness on an 8-point scale, but the percentage of consumers satisfied with overall eating quality of steaks from implanted cattle was not different from nonimplanted cattle. When all steaks in consumer panel ratings were adjusted to a common marbling score no differences were observed for tenderness, flavor or juiciness.

Pritchard et al. (2000) evaluated lifetime implant strategies and found that in 3 different lifetime implant treatments vs. a nonimplanted group there were no differences found in WBSF among the treatment groups.

More recent work has been conducted evaluating implants effects on tenderness and consumer sensory demonstrates there is little, if any, negative effect of implants on beef tenderness.

Fowler et al. (2000) evaluated 4 different implant treatments in calf-fed Holsteins, where calves were implanted 2 or 3 times during a 288-d feeding period. The authors found no differences in WBSF between implant treatments or between implanted cattle and nonimplanted controls. Milton (2000) evaluated 5 different implant strategies and found no differences in WBSF or the percentage of steaks

Table 14. Boneless subprimal and total lean yields in implanted cattle (% of side weight).[a]

Item	Control	E	TBA+E
Ribeye roll	2.9	2.8	2.9
Boneless chuck	17.9	18.2	19.3
Brisket	2.6	2.7	2.4
Knuckle	2.5	2.7	2.5
Top round	5.0	5.1	5.2
Bottom round	6.9	6.9	7.1
Striploin	3.0	3.1	3.4
Top sirloin	2.8	2.9	2.9
Bottom sirloin	1.9	1.8	2.1
Tenderloin	1.4	1.4	1.5
Total side yield increase	—	+0.81	+2.4

[a]Foutz et al., 1997.

Table 15. Effects of reimplanting with Revalor-S on carcass fabrication values of finishing beef steers.[a]

Item	No reimplant	Reimplant
Number of carcasses	30	30
Total saleable yield, %	70.1	72.6
Total fat trim, %	13.8	11.28
Total bone, %	16.1	16.2

[a]Hutcheson et al., 2007.

Table 16. Effects of estrogenic and androgenic implants on meat tenderness (WBS, kg).[a]

Item	Change from control	*P*-value
Warner Bratzler shear	+0.27 kg	0.79

[a]Ducket et al., 1996.

Table 17. Effects of growth promotant implants on tenderness (WBSF, kg).[a]

Control	Estrogen only	Estrogen/TBA	TBA/None	TBA/TBA	Change from control
3.95	4.14	—	—	—	+0.19 kg
3.39	—	3.58	—	—	+0.19 kg
3.72	—	—	4.09	—	+0.37 kg
3.59	—	—	—	3.73	+0.14 kg

[a]Nichols et al., 2002.

with > 3.9 kg of WBSF among treatment groups. Barham et al. (2003) demonstrated that *Bos indicus*-influenced cattle implanted with Syn-S/Syn-S or Syn-S/Revalor-S were not different when compared with nonimplanted cattle with respect to beef tenderness or consumer acceptability. Arseneau et al. (2004) evaluated 4 different treatments (nonimplanted controls, Revalor-IS, Revalor-S, or Revalor-IS followed by Revalor-IS and found no differences in WBSF among the 4 treatments. Cheatham and Duff (2004) evaluated 3 different implant strategies in calf-fed Holsteins and found no differences in WBSF among all treatment groups. Pritchard (1998) evaluated 5 different implant strategies and found no differences in 14-d SSF between implant treatment groups and nonimplanted cattle. In genetically identical cattle the use of TBA or TBA + E in combination had no effect on beef tenderness of strip loin, top sirloin or top round steaks, but estrogenic implants decreased tenderness in top round steaks only when compared with nonimplanted controls (Gerken et al., 1995). Reiling and Johnson (2003) evaluated the effects of 3 different implant strategies (negative control; Ralgro followed by Revalor-S; or Revalor-S followed by Revalor-S) on WBSF in experiment 1. In experiment 1, there was no difference in WBSF between control steers and steers implanted with Ralgro followed by Revalor-S, but the Revalor-S followed by Revalor-S had an increase in WBSF vs. controls. In experiment 2, one implant treatment (Component-TES (120 mg of TBA and 24 mg of E) was tested vs. nonimplanted controls. In experiment 2, there was no difference in WBSF for implanted steers vs. nonimplanted steers at 14 d of aging, but there was a difference in 5-d aged beef. In contrast Schoonmaker et al. (2001) reported no differences in shear force values or taste panel evaluations between cattle aggressively implanted (Syn-C/Revalor-S/Revalor-S) and nonaggressively implanted [Synovex-S (20 mg of estradiol benzoate and 200 mg of progesterone)/Synovex-S].

Hutcheson et al. (2007) evaluated cattle that had all received an initial implant (Revalor-IS) and which received or did not receive a terminal implant (Revalor-S). Results demonstrated when slice shear force SSF was completed on 14-d aged steaks there were no differences between the 2 treatment groups (15.8 vs. 16.3 kg) or the percentage of tender steaks (<21.5 kg) between nonreimplant and reimplanted steers (93 vs. 92%).

Schneider et al. (2007) indicated that implanting heifers with 1 or 2 TBA-only implants did not affect WBSF (11 different implant strategies). However, implanting heifers with 2 implants containing E and TBA in combination increased WBSF compared with steaks from nonimplanted heifers aged 3 and 7 d. At 14 and 21 d of aging only 3 of the 11 implant strategies were different from nonimplanted controls for WBSF and at 28 d of aging only the highest dosage combination implant strategy was different from controls in WBSF (3.66 vs. 3.27 kg). Implant treatment effects on WBSF gradually diminished as the length of postmortem aging period increased. Postmortem aging periods of 14 to 28 d were effective for mitigating the detrimental effect of implant strategies that contained 2 implants containing E and TBA in combination.

Before the publication by Schneider et al. (2007) there had been 3 papers which measured WBSF among heifers containing either implanted or nonimplanted treatment groups. In those papers 11 different implant strategies were evaluated and 2 suggested that implants increase WBSF, 8 showed no difference and 1 showed a decrease (increased tenderness) in WBSF. In the study that showed a decrease in tenderness it was with the highest dosage combination implant compared with nonimplanted heifers (Crouse et al., 1987; Nichols et al., 1996; Kerth et al., 2003).

Collectively when summarizing implant effects on WBSF in heifers there have been 4 papers completed, and these suggest that heifer implant programs exert very little effect on beef tenderness.

The body of data evaluating implant effects on shear force (WBSF or SSF) and sensory ratings by trained and consumer panels indicates there is little, if any, negative effect of growth promotant implants on the tenderness of beef.

Conclusions

It is abundantly clear that implanted cattle should be taken to their physiological maturity and that different implant programs can affect the weight at which they reach an equal body fat as their nonimplanted contemporaries. Understanding these effects will allow the industry to better utilize existing growth technologies to mitigate any negative effects on marbling and to produce affordable beef for the consumer without the risk of producing beef with tenderness issues.

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