IMPLANT PROGRAM EFFECTS ON USDA BEEF CARCASS QUALITY GRADE TRAITS AND MEAT TENDERNESS[1]

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INTRODUCTION

Anabolic implants are used to improve growth rate and feed efficiency of cattle during finishing. At the present time, nineteen different implants are commercially available. Economic benefits associated with implant use have been well documented and widely recognized. However, implants can have deleterious effects on beef quality. The National Beef Quality Audit (NBQA) identified this "reduced quality of beef due to implants" (i.e., specifically lowered marbling scores, reduced beef tenderness, increased dark cutting percentages and/or detrimental effects associated with advanced carcass skeletal maturity). Results of the NBQA estimated that the beef industry loses $7.63 for every steer and heifer slaughtered (annual loss of approximately $202 million) due to detrimental effects of implants on carcass quality. This review summarizes the effects of estrogenic and(or) androgenic implants, on beef carcass quality traits and meat tenderness.

MATERIALS AND METHODS

For this review, research results from refereed and trade journal publications (95% published after 1990) were utilized to construct an *OSU Implant Data Base*. For discussion purposes, implants were classified according to their active ingredient type (estrogen, androgen or combination) and concentration strength (mild or strong, See Table 1). Implant combinations were denoted with the two appropriate implant type abbreviations used together, reimplants are denoted by a "/" between the first implant(s) used and second implant(s) used. For example, ME/MC is the abbreviation for a "mild estrogen," (e.g., Compudose or Ralgro) implant with a reimplant of a "mild combination." (e.g., Revalor).

Table 1. Implants stratified by active ingredient type and concentration strength

Implant	Strength	Type	Abbreviation
Compudose, Ralgro	Mild	Estrogen	ME
Synovex, Implus, Magnum, Steer-oid, Heifer-oid	Strong	Estrogen	SE
Finaplix	--	Androgen	A
Revalor	Mild	Combination	MC
Synovex Plus	Strong	Combination	SC

Most research investigations have compared implant programs in which cattle were administered either a single implant or two successive implants during finishing periods of approximately 110 to 160 days. However, in an attempt to eliminate the traditional "shot gun" approach associated with implanting, U.S. beef producer's have begun to implement *"implant strategies"* in their production systems. In other words, each implant is utilized to maximize it's inherent strength's and minimize it's limitations. The end result of the implant program is to obtain the most economical gains and to improve net earnings while maintaining acceptable carcass quality. In an attempt to summarize the impact of various implant strategies on beef carcass quality traits and tenderness, research publications in the *OSU Implant Data Base* were categorized as being conservative, intermediate or aggressive implant strategies. Conservative implant strategies involve cases where a modest improvement in average daily

[1] Special thanks to Ron L. Stubbs and David N. Vargas for their assistance in collecting/obtaining research literature.

gain (ADG) is desired but high quality grade is the number one priority. One characteristic of conservative implant programs is that 100 days expires between the terminal implant and the slaughter date. Figure 1 illustrates three examples of conservative implant programs.

Figure 1. Implant Strategies In Feedlot Steers/Heifers

A. Conservative Implant Programs:

Example 1

⩛	< 70 days	⩛	> 100 days	*
ME		SE MC		Slaughter

Example2

⩛	> 70 days	⩛	> 100 days	*
SE		SE MC		Slaughter

Example 3

⩛	>100 days	*
MC		Slaughter

Examples of intermediate implant programs are shown in Figure 2. Typically, these programs are implemented when greater ADG is desirable and a slight depression of USDA quality grade is acceptable. Unlike the conservative implant programs, intermediate implanting schemes have a time window between terminal implant and slaughter date of at least 70 days.

Figure 2. Implant Strategies In Feedlot Steers/Heifers

B. Intermediate Implant Programs:

Example 1

⩛	< 70 days	⩛	> 70 days	*
ME		SE MC		Slaughter

Example2

⩛	> 70 days	⩛	> 70 days	*
SE MC		SE MC		Slaughter

Example 3

⩛	>100 days	*
SC		Slaughter

The most aggressive implant strategy is designed for maximum performance in ADG and feed efficiency with little concern for depression in marbling (See Figure 3). In this implant strategy the most potent implants are used in association with a short time window between the terminal implant and slaughter date.

Figure 3. Implant Strategies In Feedlot Steers/Heifers

C. Aggressive Implant Programs:

Example 1

⩛	< 70 days	⩛	> 70 days	*
SE MC		SE MC		Slaughter

Example2

⩛	> 70 days	⩛	70 to 100 days	*
MC SC		SC		Slaughte

RESULTS AND DISCUSSION

Many previous attempts that have summarized the influence of implants on beef carcass quality traits (i.e., marbling score, percentage U.S. Choice, skeletal maturity and dark cutters) and meat tenderness have concluded that, "Due to the lack of statistical evidence, implanting displayed no detrimental effects on beef quality grade traits or tenderness." Nevertheless, many such research reviews admitted that implanting reduced the average percentage of carcasses grading U.S. Choice or above from 0% to 28% as compared to cattle not implanted. Such differences were not *statistically significant* ($p > .05$) due to large variation across as well as within various cattle populations included in these studies. Despite lack of statistical verification, trends in quality traits and tenderness that exist due to implant type, strength and status certainly have practical importance.

Marbling Score and Percentage Choice: Mean marbling scores and percentage U.S. Choice responses for carcasses from nonimplanted cattle, and the change due to implant strength and type are presented in Table 2.

Table 2. Marbling score and percentage Choice change stratified by implant strength and type[a].

First implant	Second implant	Third implant	Marbling score	Choice, %
Non-implanted			436[b]	78.5
ME[c]	---	---	-12[d]	-4.9[d]
ME	ME	---	-16	-5.7
ME	ME	ME	-12	-3.5
A	---	---	-9	-4.2
A	A	---	NA[e]	-2.1
ME/A	ME/A	---	-12	-9.3
SE	---	---	-24	-14.3
SE	SE	---	-47	-24.0
SE/A	---	---	-19	-6.2
SE/A	SE/A	---	-24	-24.0
MC	---	---	-12	-23.0
MC	MC	---	-26	-24.0
SE	MC	---	-21	-23.0
SC	---	---	-29	-20.0
SC	SC	---	-20	-26.0

[a]Source: OSU Implant Data Base.
[b]Marbling score: 400 to 499 = Small.
[c]Implant classification: ME, SE, A, MC and SC are mild estrogen, strong estrogen, androgen, mild combination and strong combination, respectively. See Table 1.
[d]Change in marbling score and percentage Choice compared to nonimplanted controls.
[e]NA = not available.

Based on research information included in this review, implants did numerically reduce marbling scores and the percentage of carcasses grading U.S. Choice or higher. Cattle which were administered multiple (≤ 3) ME implant(s) reduced the percentage of carcasses grading Choice by approximately 5 percentage points (Table 2). However, when a ME implant was used in conjunction with an A type implant, the reduction in grading (Choice or higher) carcasses was approximately double (78.5% for control versus 69.2% for implanted cattle). The reduction in marbling score and percentage of carcasses grading Choice was more drastic when cattle received a single SE implant. Compared to carcasses originating from nonimplanted cattle, marbling score and percentage of carcasses grading Choice or higher was reduced by approximately 24% and 14%, respectively. When multiple SE implants were utilized during the finishing period, marbling score was reduced by 47 percentage points and the depression in carcasses grading Choice was 24%. There is a general perception in the U.S. beef industry that implants containing trenbolone acetate (TBA) reduces marbling score and the percentage of carcasses grading Choice. According to the results generated from the *OSU Implant Data Base*, compared to nonimplanted controls, cattle implanted with a TBA-containing implant (MC and SC) produced approximately 25% fewer carcasses grading Choice or higher. Regardless of implant administration frequency (1 or 2 implants) or strength (mild or strong), for every four cattle receiving MC and(or) SC implants only 2 carcasses would grade U.S. Choice or higher compared to 3 out of every 4 carcasses from nonimplanted cattle.

Effects of implants on marbling scores and percentages of carcasses grading Choice is greatest if the implant is administered late in the finishing period. Correspondingly, to avoid quality grading problems, suppliers of implants recommend that implants be used no less than 70 days prior to slaughter. Research trials that included SE. A and MC implants were divided into two separate implant frequency categories: (1) **less** than 70 days between terminal implant and slaughter and (2) **greater** than 70 days between terminal implant and slaughter. Compared to the longer implant frequency (> 70 days), when the implant was given less that 70 days prior to slaughter. percentage of carcasses grading Choice or higher was markedly reduced (Figure 4).

This reduction in marbling score and quality grade is most detectable when a SE implant was administered during this crucial period prior to slaughter.

Implant type and strategy may interact with genotype to influence carcass quality grade. Many research investigations have noted that the detrimental effect implant type on quality grade tends to be greater with Continental-European (i.e., "Exotics) breeds than British breeds of cattle. In an attempt to address this theory, research studies were subdivided by the biological type of research cattle (British, British/Exotic cross, Dairy), gender (steer or heifer) and implant strategy used (nonimplanted, conservative, intermediate or aggressive). Results are in Figure 5. As implant strategy moved from conservative to aggressive, the British/Exotic crossbred population responded by producing fewer and fewer carcasses grading U.S. Choice or higher. This depression was less dramatic among the other biological types.

Skeletal Maturity: The 1996 USDA beef quality grading standards are based upon the amount of marbling present in the ribeye at the 12^{th}-13^{th} rib interface and the maturity of the carcass. Marbling has long been the major focus commonly associated with the eating quality of beef. Maturity often has been overlooked and, until recently, often not considered in the beef quality equation. However, the beef quality grading system was changed January 31, 1997. Under the new grading standards, carcasses with a combined lean and skeletal maturity score of "B," (See Table 3) having only Small or Slight degrees of marbling will be excluded from the Choice and Select grades. Instead, these carcasses will be graded standard. According to a USDA audit, this new grading standard should affect only 1.58% of all fed cattle in the U.S. Although proposed grade change potentially can impact all groups of fed-beef cattle, heiferettes and aged cattle, e.g of Mexican origin, likely will be affected most.

Table 3. The approximate chronological age with increasing physiological maturity.

Carcass Maturity Group[a]	Approximate Chronological Age
A	9 to 30 months
B	30 to 42 months
C	42 to 72 months
D	72 to 96 months
E	> 96 months

[a]The physiological maturity of a carcass is an estimate of the animal's real chronological age.

With this change in the beef quality grading system, carcass maturity has become more of a "top of mind" issue. Early maturing breed types, puberty and pregnancy, endogenous hormone levels, mineral balance of water and rations as well as excessive exogenous hormone supplementation (i.e., implanting) all are being investigated for their impact on beef carcass maturity. Information is limited concerning the effect of implants on beef carcass maturity. Using the information from the *OSU Data Base,* the means in Table 4 were generated for the impact of implant strength and type on beef carcass maturity.

Carcasses from cattle which were implanted with anabolic implants tended to have more advanced skeletal maturity than carcasses from nonimplanted cattle. Additionally, skeletal maturity was more advanced for carcasses from aggressively implanted cattle than conservative or intermediate implanting strategies. In the future, research scientists should collect and report information on all beef quality traits (marbling, skeletal and lean maturity, dark cutter occurrence) as well as meat tenderness for both steer and heifer carcasses.

Dark Cutting Beef: Dark cutting beef (DCB) or "dark cutters" costs the U.S. cattle industry approximately $132 million per year. Most research scientists believe DCB is a result of depletion of muscle glycogen stores prior to slaughter. Glycogen serves as the major storage carbohydrate in skeletal muscle tissue. In a normal animal, glycogen represents about 1% of muscle weight. However, muscle glycogen stores can be depleted by stress associated with physical activity, emotional excitement or acute changes in environmental conditions. Factors such as transportation conditions (time, ambient temperature, precipitation), handling conditions (during loading, transit, unloading and driving to stunning chute) are examples of preslaughter stressors. Anabolic implants alone do not cause DCB. Rather synergism between certain growth implants and preslaughter stressors may

exacerbate the problem. That is, cattle treated with growth implants are more likely to become "stressed."

Table 4. Steer carcass skeletal maturity change stratified by implant strength, type and strategy[a].

First implant	Second implant	Skeletal maturity
Non-implanted		**A[44b]**
ME[c]	---	A[44]
ME/A	ME/A	A[60]
SE	---	A[53]
SE	SE	A[62]
SE/A	---	A[54]
SE	SE/A	A[62]
MC	---	A[53]
MC	MC	A[60]
SC	---	A[60]
SC	SC	A[65]
Implant Strategy		
Conservative		A[51]
Intermediate		A[54]
Aggressive		A[65]

[a]Source: OSU Implant Data Base.
[b]Change in skeletal maturity compared to nonimplanted controls.
[c]Implant classification: ME, SE, A, MC and SC are mild estrogen, strong estrogen, androgen, mild combination and strong combination, respectively. See Table 1.

There is a perception in the U.S. beef industry that use of trenbolone acetate (TBA) containing implants causes a higher incidence of DCB carcasses. Information generated through the *Data Base* on the influence of implant strength and type on occurrence of DCB suggests that this perception could be true (Figure 6).

Compared to the nonimplanted control animals (DCB percentage of 0.17), carcasses from animals receiving an androgen-based implant produced a higher percentage of DCB carcasses. However, research information does not support a direct relationship between administration of TBA and incidence of DCB. Although it is unlikely that TBA implants have a direct effect on the incidence of DCB, cattle treated with TBA maybe more predisposed to developing the DCB condition when subjected to other stressful conditions. Concern regarding the effect of anabolic implants on DCB likely will continue until definitive research studies on DCB are more definitive.

Meat Tenderness: The 1994 Food Marketing Institute TRENDS Report concluded that "Taste" ranked first among "Factors Important In Food Selection" by U.S. supermarket shoppers. Consumers consider three characteristics – flavor, tenderness and juiciness – as they evaluate "palatability" and(or) "eating quality," (i.e., the satisfaction received by eating beef). Many research projects have identified tenderness as the most important factor of these three characteristics in determining consumers' perception of taste. In 1993, Texas A&M University meat scientists determined that one tough beef carcass could negatively impact 542 consumers. Although (a) only one-tenth of 1 percent of tough, dry or bland steaks are returned for replacement or refund, (b) for every one complaint that is vocalized, ten complaints are never heard, and (c) most consumers who have had a bad eating experience don't complain – *they just don't come back.*

Only a limited amount of information is available concerning the effects of implants on beef tenderness. Results regarding the impact of anabolic implants on meat tenderness are summarized in Table 6. Summarization of WBS data from various universities and research institutions can be misleading because postmortem aging times utilized at the various locations are not consistent. Hence, these values should be interpreted cautiously. Overall, Warner-Bratzler shear force value (WBS) of loin steaks was approximately 1.10 lb.greater for implanted than nonimplanted cattle (Table 5).

Postmortem aging, as a method for tenderization of meat by storage at or above freezing temperatures, is very important in assuring a tender and acceptable meat product. Generally, as postmortem aging time increases, meat tenderness increases. In an attempt to draw inferences on the impact of various implant management styles on the response of beef steaks to the postmortem aging process and ultimate tenderness, WBS information from the *OSU Implant Data Base* was segregated by aging times and implant strategies (See Figure 7).

Regardless of postmortem aging time, steaks were from tougher from aggressively implanted than from nonimplanted or conservatively implanted cattle. It appears that even after 21 days of postmortem aging, WBS of steaks originating from cattle which were intermediately or aggressively implanted had a WBS similar to that of

Table 5. Warner-Bratzler shear force value change stratified by implant strength and type[a].

First implant	Second implant	Third implant	WBS[b], lb.
Non-implanted			8.00
ME[d]	---	---	+.10
ME	ME	ME	+.93
A	---	---	+1.30
ME/A	ME/A	---	+1.57
SE	---	---	+.94
SE	SE	---	+.97
SE/A	---	---	+1.08
SE/A	SE/A	---	+1.40
MC	---	---	+.25
MC	MC	---	+1.70
SC	---	---	+1.70
SC	SC	---	+1.30

[a]Source: OSU Implant Data Base.
[b]WBS: Warner-Bratzler shear force value, lb.
[c]Change in WBS compared to nonimplanted controls.
[d]Implant classification: ME, SE, A, MC and SC are mild estrogen, strong estrogen, androgen, mild combination and strong combination, respectively. See Table 1.

nonimplanted control steaks at 7 days of aging. In other words, meat from the more aggressive implant strategies responded to postmortem aging; but, the time required for steaks to become as tender as meat from nonimplanted or conservatively implanted cattle was much longer.

The meat industry – like the retail clothing business – has adopted the "Just In Time" (JIT) delivery system. The JIT system allows an individual retail outlet to communicate electronically with its supplier to reorder specific items which are selling quickly. The entire distribution system thereby becomes more efficient because box beef can be plant-assembled, palletized and delivered to individual retail store orders. Short-haul delivery times of 5 days can now be reduced to a 2 day store arrival; a typical long-haul delivery that takes approximately 11 days can be reduced to only 5 days. This all means that the beef industry has and will continue to have less time for the postmortem aging that enhances tenderness.

CONCLUSION

The entire beef production system must become more customer oriented if it is to maintain its current market share. To accomplish this goal, implant strategies must balance the advantages in growth against reductions in meat palatability. Cooperation, initiative and investment from all involved parties is essential for solving problems associated with consumer acceptability of beef.

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