

/EFFECTS OF FINAPLIX®, SYNOVEX-S® AND RALGRO® IMPLANTS,  
SINGULARLY OR IN COMBINATIONS, ON PERFORMANCE, CARCASS  
TRAITS AND LONGISSIMUS PALATABILITY OF HOLSTEIN STEERS/

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### DEDICATION

Being an only child, I have always had a very close, tight family circle. Therefore, my thesis is dedicated to my parents, Ken and Linda Apple. It is through the never-ending love and support of my parents that I have been able to achieve this goal and all the goals that I have previously set. Furthermore, I would feel remorse if I did not acknowledge my grandparents, Lucille Thompson, along with Gussie and Fred Loughridge for their love and encouragement in pursuing my education to this point and beyond. I will never be able to repay my family for what they have sacrificed for me over the years; however, I can express my deepest love and appreciation. Thank you all!

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## CHAPTER I

### GENERAL INTRODUCTION

The demand for lean beef has fueled a renewed interest in Holsteins as a lean-beef producing breed. The leading dairy states of Wisconsin, California and Minnesota, have surpluses of Holstein steers that are fed in numerous feedlots across the United States. California leads the way in rearing Holstein steers that go to the feedyards at a young age. Packerland and Excel are the only major packers committed to Holstein slaughter and they slaughter up to 1500 to 1800 head per day, respectively (Kay, 1988).

Holsteins have been shown to gain at equal or faster rates when compared to Angus, Hereford, Brahman, Brahman-crosses, Santa Gertrudis, Jersey, Hereford X Angus and Simmental X Holstein steers (Cole et al., 1963; Garcia-de-Siles et al., 1977; Wyatt et al., 1977; Young et al., 1978; Crosthwait et al., 1979; Newland et al., 1979; Thonney et al., 1981; Thonney, 1987). Holstein steers have one definite advantage over typical beef breeds, in that Holstein carcasses have less external fat than most beef breeds (Cole et al., 1963; Charles and Johnson, 1976; Dean et al., 1976; Wyatt et al., 1977; Young et al., 1978; Newland et al., 1979; Crosthwait et al., 1979; Nour et al., 1981, 1983; Bertrand et al., 1983). Furthermore, it has been reported that Holstein steers are superior in yield grade when compared to some beef breeds (Cole et al., 1963; Young et al., 1978; Bertrand et al., 1983; Nour et al., 1983).

Research concerning marbling and quality grades of Holstein carcasses, as they compare to typical beef breeds, is contradictory to say the least. Some authors have reported that Holstein carcasses displayed more marbling than Brahman and beef crossbred cattle (Wellington 1971; Dean et al., 1976; Wyatt et al., 1977; Young et al., 1978). However, others have found Holsteins to be comparable to or inferior to beef breeds in marbling (Cole et al., 1963; Ziegler et al., 1971; Dikeman et al., 1977; Garcia-de-Siles et al., 1977; Young et al., 1978; Crosthwait et al., 1979; Bertrand et al., 1983; Nour et al., 1983).



A major disadvantage of the Holstein breed is their low muscle-to-bone ratio, as measured either by longissimus muscle area or carcass conformation. Holstein cattle have been shown to have smaller or comparable longissimus muscle areas to British breeds (Cole et al., 1963; Dean et al., 1976; Garcia-de-Siles et al., 1977; Nour et al., 1983) or Brahman crossbred cattle (Cole et al., 1963). In addition, Cole et al. (1963), Wellington (1971) and Young et al. (1978) found that carcasses from Holstein cattle received lower conformation scores than typical beef breeds.

Steaks from Holstein cattle have been found to be superior to, or comparable to steaks from beef breeds for Warner-Bratzler shear-force values, and sensory-panel ratings for flavor, juiciness and tenderness (Cole et al., 1963; Ziegler et al., 1971; Garcia-de-Siles et al., 1977; Lalande et al., 1982).

Finaplix, an implant containing the androgenic, anabolic-steroid trenbolone acetate, has been shown to increase growth rate in steers (Roche et al., 1978; Brethour, 1986; Trenkle, 1987). Moreover, when Finaplix is administered in combination with an estrogenic anabolic agent, an additive effect on growth has been noted (Galbraith and Watson, 1978; Galbraith and Dempster, 1979; Heitzman et al., 1981; Unruh, 1986). Galbraith and Coelho (1978) reported that steers implanted with Finaplix and hexoestrol, had 40% increased ADG over non-implanted steers. Trenkle (1987) reported that implanting steers with Finaplix and estradiol improved ADG by 19.9% when compared to untreated steers. Also, combinations of Finaplix plus Ralgro and Finaplix plus Synovex-S have been shown to increase ADG dramatically over non-implanted cattle (Brethour and Schanbacher, 1983; Keane et al., 1986; Keane and Sherington, 1985a,b; Brethour, 1985; 1986; Silcox et al., 1986; Keane, 1987). Feed efficiency of cattle implanted with Finaplix-combinations also has been improved over controls (Galbraith and Coelho, 1978; Galbraith and Watson, 1978; Galbraith, 1979b; Galbraith and Dempster, 1979; Galbraith and Geraghty, 1982; Fabry et al., 1983).

Cohen and Cooper (1983) reported that longissimus muscle area of steers treated with Ralgro was greater than that of untreated steers. Furthermore, steers implanted with Synovex-S had greater longissimus muscle areas than controls (Rumsey, 1982; Lomas, 1983). Galbraith et al. (1981)

and Trenkle (1987) both reported that treatment of steers with trenbolone acetate and estradiol increased longissimus muscle area when compared to untreated steers. In general, anabolic agents have also been shown to reduce fat thickness, percent internal fat, yield grade, marbling and U.S.D.A. quality grade, while increasing carcass weight and carcass conformation.

Because of the low muscle-to-bone ratio and the reports that anabolic agents may increase muscle mass, Holstein steers would benefit the most from implantation. Furthermore, the effects of anabolic agents and androgenic-estrogenic combinations on Holstein steer meat palatability are unknown. Therefore, the objectives of our study were to determine the effects of implanting Holstein steers with Finaplix<sup>®</sup>, Ralgro<sup>®</sup> and Synovex-S<sup>®</sup>, as well as combinations of Finaplix plus Ralgro and Finaplix plus Synovex-S, on (1) live animal performance, masculinity and ease of hide removal; (2) carcass conformation and LM area, and (3) longissimus meat palatability.

## CHAPTER II

### GENERAL REVIEW OF LITERATURE

#### HOLSTEIN BEEF

The demand for lean beef has fueled a renewed interest in the Holstein breed as a lean beef producing breed. California is leading the way in rearing Holsteins that go directly to the feedyards at 3 to 6 mo of age. Packerland and Excel are the only major packers committed to Holsteins and they slaughter up to 1500 to 1800 per day, respectively (Kay, 1988). The utilization of Holsteins as a source of lean beef was one reason for the use of this breed in our study.

Holsteins typically gain at competitive rates when compared to other beef breeds. Holsteins have been found to outgain Angus (Cole et al., 1963; Newland et al., 1979; Thonney et al., 1981; 1987), Hereford (Cole et al., 1963; Garcia-de-Siles et al., 1977; Thonney, 1987), Brahman, Brahman-crosses, Santa Gertrudis and Jersey (Cole et al., 1963). However, Garrett (1971) reported that Holstein cattle were outgained by Herefords. In studies comparing performance of breed types, Holstein steers gained more than Holstein X Limousin steers and heifers (Forrest, 1981) and Brahman-sired steers (Young et al., 1978). Furthermore, research has shown that Holsteins gain at a rate similar to Hereford crossbred steers (Wyatt et al., 1977), Hereford X Angus calves (Young et al., 1978; Crosthwait et al., 1979) and Simmental X Holstein steers and heifers (Forrest, 1980). Also it has been shown that Holstein cattle gained less than Charolais X Holstein steers and heifers (Forrest, 1977) and Hereford X Charolais and Hereford X Holstein X Charolais steers (Dean et al., 1976). Therefore, Holstein cattle gain at rates competitive with most typical beef breeds.

Literature concerning feed efficiency has been conflicting when comparing Holsteins to other breeds of cattle. Holsteins required the fewest days to slaughter and required the least amount of feed per 45.5 kg of gain when compared to all other breeds (Cole et al., 1963). Other reports indicate that Holstein steers were more efficient than Hereford steers (Garcia-de-Siles et al., 1977; Thonney, 1987) and Angus steers (Thonney et al., 1981, 1987). However, Hereford X Angus

and Hereford X Charolais cattle were more efficient than Holstein cattle (Newland et al., 1979). Furthermore, other studies have found that Holsteins are less efficient in converting feed to gain than purebred-beef breeds and beef breed crosses (Garrett, 1971; Dean et al., 1976; Crosthwait et al., 1979), and beef X dairy crosses (Dean et al., 1976; Wyatt et al., 1977; Forrest, 1980, 1981).

In today's beef packing industry, quality grade plays an important role in segregating beef carcasses into different price categories. An important factor in quality grading is the amount of intramuscular fat or marbling deposited in the longissimus muscle (LM). Research has shown that Holstein carcasses have more marbling than Hereford X Charolais, Hereford X Holstein X Charolais (Dean et al., 1976; Wyatt et al., 1977), Brown Swiss (Bertrand et al., 1983) and Brahman (Young et al., 1978). Holsteins had comparable amounts of marbling to Hereford X Angus (Crosthwait et al., 1979), Hereford (Bertrand et al., 1983), Charolais (Ziegler et al., 1971), Devon (Young et al., 1978) and Brahman crosses (Cole et al., 1963). On the other hand, Holsteins displayed less marbling than Hereford (Cole et al., 1963; Ziegler et al., 1971; Garcia-de-Siles et al., 1977; Young et al., 1978), Polled Hereford (Ziegler et al., 1971), Angus (Cole et al., 1963; Ziegler et al., 1971; Young et al., 1978; Bertrand et al., 1983; Nour et al., 1983), Santa Gertrudis, Brahman-crosses and Jersey steers (Cole et al., 1963). Therefore, it has been shown that Holstein carcasses have similar amounts of marbling when compared to British and continental-beef breeds, and usually have superior marbling scores when compared to Zebu and Zebu-crossbred cattle.

Another factor involved in quality grading is color of the LM. Wellington (1971) reported that the color of cuts of beef from dairy cattle was less stable than that from typical beef breeds when held under various temperatures in retail counters. However, Garcia-de-Siles et al. (1977) measured percent reflectance of eight muscles from Holstein and Hereford steers and found that Holstein muscles had a greater reflectance than those from Herefords.

Quality grade data are not presented in this literature review because many of these studies were conducted when carcass conformation was a factor in determining carcass quality grade. Therefore, it would be confusing to report differences in quality grade when, in many studies,

conformation was instrumental in lowering the quality grade of Holstein carcasses.

One definite advantage Holstein cattle have over beef breeds is that Holstein cattle have less fat cover than most beef breeds. Holstein carcasses have been found to have less fat cover than Hereford (Cole et al., 1963; Charles and Johnson, 1976; Dean et al., 1976; Wyatt et al., 1977; Young et al., 1978; Newland et al., 1979; Crosthwait et al., 1979; Bertrand et al., 1983), Angus (Cole et al., 1963; Charles and Johnson, 1976; Nour et al., 1981, 1983; Bertrand et al., 1983), Angus X Hereford (Crosthwait et al., 1979; Newland et al., 1979), Hereford X Holstein X Charolais (Dean et al., 1976; Wyatt et al., 1977), Hereford X Charolais (Newland et al., 1979), Brahman and Brahman-crosses (Cole et al., 1963; Young et al., 1978), Santa Gertrudis (Cole et al., 1963), Devon (Young et al., 1978), Brown Swiss (Bertrand et al., 1983) and Jersey (Cole et al., 1963).

Longissimus muscle area is a measure of muscling in beef carcasses and is a factor in the U.S.D.A. yield grading equation. In comparison with other beef breeds, Holstein cattle have been found to have significantly smaller LM areas than Hereford (Garcia-de-Siles et al., 1977), Angus (Cole et al., 1963; Nour et al., 1983) and Santa Gertrudis (Cole et al., 1963). It has also been reported that Holstein cattle had comparable LM areas with Hereford (Cole et al., 1963; Dean et al., 1976; Bertrand et al., 1983) and Brahman (Cole et al., 1963). Finally, Nour et al. (1981) reported that when LM area was held constant, wholesale ribs of Holsteins had more dissectable muscle than Angus, indicating that the LM is longer in Holstein than in Angus steers.

Cole et al. (1963) and Dean et al. (1976) found that Holstein steer carcasses did not differ in percent kidney, heart and pelvic fat, when compared to Angus, Brahman-crosses, Brown Swiss, Hereford and Santa Gertrudis steer carcasses. However, Garcia-de-Siles et al. (1977) reported that Holstein steer carcasses tended to have higher percents of kidney knob when compared to Hereford carcasses. This is in support of the findings of Charles and Johnson (1976), who found that Holstein carcasses had significantly more internal fat than Hereford and Angus carcasses, but were similar to Charolais carcasses in kidney fat percentage. In a study comparing Holstein and Angus steers slaughtered at one of five weights (ranging from 363 to 612 kg), Nour et al. (1983) indicated

that at lighter weights, Angus carcasses had greater percents of internal fat; however, at the heavier weights, Holstein carcasses had significantly greater percents than Angus. Dikeman et al. (1977) reported that Holsteins had a higher proportion of their total fat as kindly and pelvic fat when compared to heavy (318 to 340 kg) and light (227 to 250 kg) British steers. On the other hand, Young et al. (1978) reported that Holstein-sired steers had the smallest percent kidney, heart and pelvic fat when compared to steers sired by Angus, Brahman, Charolais, Devon, Hereford, Jersey, Limousin and Simmental bulls. Therefore, literature comparing percent internal fat of Holsteins to typical beef-breeds is scarce and contradictory, to say the least. However, it can be concluded that Holsteins have percentages of kidney, heart and pelvic fat is equivalent or in excess than most beef breeds.

The Holstein breed has been reported to be superior in U.S.D.A. yield grade to beef breeds (Cole et al., 1963; Young et al., 1978; Bertrand et al., 1983; Nour et al., 1983), especially if Holsteins are slaughtered at a young age.

The final area of discussion deals with the ultimate indicator of beef quality, that of sensory evaluation. Two primary tools of sensory evaluation, Warner-Bratzler shear (WBS) force and sensory panel (SP) evaluation, have been used to compare Holsteins to beef breeds.

Cole et al. (1963) found that loin steaks from dairy steers were the most tender, having the lowest WBS values. Also, Lalande et al. (1982) reported that Holstein steers had lower WBS values than Maine-Anjou X Holstein steers; however, Limousin-, Blonde D'Aquitaine- and Chianina-Holstein crossbred steer carcasses were not different from Holstein steers in WBS measured tenderness. This supports the findings of Ziegler et al. (1971) that Holstein beef did not differ in WBS values from that of beef breeds.

When reviewing the literature pertaining to SP ratings of steaks from Holstein cattle, it has been shown that Holsteins had superior flavor and tenderness ratings when compared to Holstein crosses with Maine-Anjou, Limousin, Chianina and Blonde D'Aquitaine of similar weights (Lalande et al., 1982). Holstein steers were rated higher for tenderness than Charolais and Hereford heifers,

Polled Hereford X Angus X Holstein steers and Holstein bulls: and lower than Shorthorn steers and Angus X Angus X Holstein and Hereford X Angus X Holstein heifers (Ziegler et al., 1971). Also, Ziegler et al. (1971) found that Holstein steers were rated lower for flavor than were Angus, Hereford or Shorthorn steers, Angus X Angus X Holstein or Hereford X Angus X Holstein steers and heifers. Hereford steaks scored higher in flavor when compared to Holstein steaks (Garcia-de-Siles et al., 1977; Ziegler et al., 1971). However, Cole et al. (1963) found no differences in either a professional or family panel's ratings for tenderness, juiciness and flavor, with the exception that the family panel scored steaks from dairy type steers more tender than British or Zebu breed types. Therefore, Holstein beef is similar to, if not superior to beef from typical beef-breeds for palatability, as determined by WBS or trained sensory panels; however, more research on the palatability of Holstein beef is needed.

#### GROWTH AND PERFORMANCE AS AFFECTED BY ANABOLIC AGENTS

The anabolic compound zeranol (6-(6,10 dihydroxyundecyl)-Beta-resorcylic acid-lactone) was developed from the estrogenic compound zearalenone produced by the maize mold *Gibberella zeae* (Galbraith and Topps, 1981). Perry et al. (1970) was one of the first researchers to report significant improvements in growth rate when cattle were administered a subcutaneous implant containing zeranol (Ralgro). They reported that heavy steers showed a 9% gain response to either 36 mg diethyl-stilbestrol (DES) or a 36 mg Ralgro (R) initial implant in a 118 d finishing trial. Also, it was reported that yearling steers gave a 13% response over the first 56 d of a finishing trial to an initial 36 mg R implant. Sharp and Dyer (1971) reported that the administration of 36 mg of R increased gains by 25.9% for steers fed wheat; 19.4% for those fed barley and 14.3% for those fed corn. Furthermore, 36 mg of R increased growth rate by 21% for cattle fed a 12% crude protein ration and 14% for the 18% crude protein ration. Borger et al. (1973) reported that steers implanted with R gained 7.8% faster than non-implanted steers over a 169 d trial. Fontenot et al. (1973), Roche et al. (1978), Keane (1983), Cole et al. (1984), Cain et al. (1986) and Thonney (1987)

have reported that growth rates of steers implanted with R have been shown to be improved by 9.5% to 22% compared with that of non-implanted steers. In a study comparing the effects of R on Holstein steers, Donovan et al. (1983) reported that R-implanted steers averaged 9.2% greater average daily gain (ADG) at 90 d and 9.5% greater at the end of the 180 d trial than control steers.

With an interest in producing lean beef by feeding bulls in the same manner as steers, several research projects were conducted to determine the effects of R on bulls live weight gain. Gregory and Ford (1983) reported that bulls implanted with 36 mg of R twice or implanted with 72 mg of R once did not differ from each other in rate of gain, but averaged 11.1% faster gains during the 141-d feeding period than bulls not implanted. Also, Kirk and Cooper (1983) reported that R improved daily gain of Friesian bulls by 170 g/d over non-implanted Friesian bulls, and that R improved gain of Holstein bulls by 50 g/d over controls. Furthermore, results of experiments by Price et al. (1983) and Vanderwert et al. (1984) showed significant increases in ADG in R-implanted bulls when compared to C bulls. Moreover, Greathouse et al. (1983) showed that R significantly improved ADG by 6.5% from birth to the time the bulls were placed on feed. From the beginning of the feedlot phase until the first group of bulls were slaughtered (196 d), R-treated bulls gained 9.3% faster than C. However, Ford and Gregory (1983) reported that R did not significantly effect ADG of bulls, but they didn't begin implanting until after weaning. Gray et al. (1986) reported that although ADG were similar for R- and C bulls for the entire feeding period, C bulls increased in weight faster from 7.7 through 9.5 mo of age and from 11.3 to 12.2 mo of age, whereas R bulls increased in weight faster from 12.2 through 14.1 mo of age.

In the experiment conducted by Sharp and Dyer (1971), R resulted in increases in ADG by 14% for heifers fed 70% concentrate; 72 mg of R increased ADG 9.5% over 36 mg of R and 25% over C heifers. Utley et al. (1976) supported these findings when they concluded that ADG of heifers implanted with R were significantly greater than gains of C heifers. Simms et al. (1983) reported that R-implanted heifers gained 6.1 kg more and reimplanted heifers gained 9.9 kg more than C heifers. Lane et al. (1986) reported that between days 1 and 86, ADG was significantly



improved for R-implanted Holstein heifers over C.

Synovex-S (S) is the trade name of the subcutaneous implant containing the combination of estradiol-17 $\beta$  benzoate and progesterone. Rumsey and Oltjen (1975) and Rumsey (1978) have shown that S implants improved ADG of steers by 25% over C. Dinius et al. (1978) also showed that S increased ADG over C (1.21 kg/d v. 0.85 kg/d). Dinius et al. (1976) reported a 35% increase, while Prior et al. (1978) reported a 27% increase in ADG compared with C steers. Other research has reported improvements in ADG by S implants from 8.2% to 23% over C (Dinius and Baile, 1977; Kahl et al., 1978; Rumsey, 1982; Lomas, 1983).

Finaplix (F) contains the androgenic, anabolic steroid trenbolone acetate (androst-4,9(10), 11-trien-3-one-17-acetate). Work with heifers showed that 300 mg of trenbolone acetate significantly improved ADG by approximately 37.6% (Best, 1972). Heitzman and Chan (1974) reported that when total weight gains were taken over a 4- or 8-wk period after implantation, the F-treated heifers gained more than C. The total weight gain of their heifers implanted for 8 wk was 62.2 kg and this was 25.6 kg more than C (71% improvement). Galbraith (1980) concluded that heifers treated with F had an average improvement in ADG by about 23% over C. Henricks et al. (1982) and Garnsworthy et al. (1986) both reported significant improvements in ADG by implanting heifers with trenbolone acetate. However, Crouse et al. (1987) reported that heifers implanted with F tended to have only slightly improved ADG when compared to C.

Effects of F on steer gains has not been researched that thoroughly; however, Brethour (1986) reported that implanting steers with F significantly increased ADG by 9% over C, which was about half the response obtained with R or S implants. Trenkle (1987) reported that implanting steers twice with F increased ADG by 6.9%; Roche et al. (1978) showed a significant effect of F on ADG of steers finished on pasture; however, in the overall analysis, F had no effect on final live weight or carcass weight. In a study dealing with F implanted bulls, Galbraith (1982) concluded that ADG were significantly improved following implantation.

The previously cited literature dealt with comparisons between implant treatment and non-

implanted controls. However, comparisons between implant types also has been conducted. Smithson et al. (1973) conducted an experiment that consisted of six trials comparing S, 12 mg DES, 15 mg DES, R and a combination of testosterone and DES. In trials one and two, S-implanted cattle had higher ADG than all other groups. In trials three, four and five, S cattle outgained those implanted with 12 mg DES, R and testosterone plus DES (Smithson et al., 1973). However, during the grazing period, as well as over the total feeding period of trial six, R-implanted cattle had greater ADG than 12 mg DES, testosterone plus DES, S-implanted and C steers. Embry et al. (1976) compared gains of steers implanted with DES, S and R and concluded that all implant treatments resulted in faster ADG than C by 5.4, 10.0 and 7.9%, respectively. The differences shown for S and R over C were significant, but there were no significant differences among types of implant. Rust et al. (1986) reported that both S and R increased ADG of Holstein steers by 14.6% in the light group (less than 454 kg), but decreased ADG in the heavy group (greater than 454 kg); however, there were no differences among treatment groups. In studies comparing R, S and Compudose (COMP) (estradiol-17 $\beta$ ), Brethour (1983) reported that cattle implanted with R gained the most and there was little difference in ADG of S and COMP cattle. However, Kercher et al. (1984) showed that 112 d gains were significantly lower in R-implanted steers than in S or COMP-implanted cattle.

Literature on estrogenic and androgenic anabolic compounds suggests that their modes of actions on growth may differ, and when administered together may provide an additive effect on growth (Unruh, 1986). Galbraith and Watson (1978) reported that from 0 to 70 d, steers treated with hexoestrol (a compound similar in structure and action to DES) plus F, hexoestrol alone or F alone, all gained more weight, in descending order of magnitude, than C. Furthermore, Galbraith and Coelho (1978) reported that steers implanted with F in combination with hexoestrol had 40% increased ADG over C steers. In the first of two trials, Heitzman et al. (1977) reported that the increase in ADG over C after 64 d of treatment was 8, 12 and 38% for F, hexoestrol and F plus hexoestrol, respectively. During the second trial comparing C to the F-hexoestrol combination given

once or twice, ADG were 18 and 19 kg greater, respectively than C. Sixty-four days after reimplantation of the third group, ADG were 22 and 32 kg greater for the F plus hexoestrol-treated groups receiving the combination once or twice, respectively (Heitzman et al., 1977). In an interesting experiment, Galbraith and Geraghty (1982) reported a 0.49 kg/d improvement in ADG for hexoestrol plus F-implanted steers during feeding period A (34 d on adequate feed) over C. During restricted feeding for 46 d (period B), the combination group lost significantly less than C, and following realimentation in period C (refed on a stair-step increase in energy for 30 d), implanted steers gained more than C. Galbraith and Dempster (1979) also reported a significant improvement in ADG by implanting with hexoestrol and F in combination compared to non- or sham-implanted steers.

When experimenting with the hexoestrol-F combination in bulls, Galbraith (1979b) reported significantly higher total weight gain (97.3 kg v. 77.3 kg) than in C bulls. This supported the results of Galbraith and Coelho (1978) who found that bulls implanted with the combination of F and hexoestrol gained 6% faster ( $P > .05$ ) than C.

Another implant combination that has been researched is trenbolone acetate and estradiol- $17\beta$ , which are the components of the implant Revalor (REV). Grandadam et al. (1975) was one of the first researchers to observe the effects of REV on ADG. It was concluded that REV-treated veal calves had greater ADG in each trial, but differences were statistically significant in only three of six trials. This supported the findings of Gropp et al. (1974), who concluded that REV-implanted veal calves, on the average, showed an increase in ADG of 14% over non-implanted calves. Henricks et al. (1988) reported that REV increased ADG significantly in steers. When ADG was examined according to the three implant periods (0, 10 and 18 wk), REV-treated steers outgained C during the first and third periods. Galbraith et al. (1983) showed that steers implanted with REV gained more weight than C in the first 28 d (+12 kg) and second 28 d period (+23.5 kg). During the last 28-d period, however, only a small difference in gain was noticed. This supported the results of Trenkle (1987) who found an increase in ADG of 19.9% when steers were

implanted with REV. Lobleby et al. (1985) reported an increase of 50% in ADG in REV-treated steers and Galbraith et al. (1981) found that REV-treated steers had significantly higher live weight and carcass gains. Fisher et al. (1986b) found that REV-treated steers were similar in ADG to non-implanted bulls. In a study comparing REV, implanted in only one ear, and treatment of F in one ear and estradiol in the other, Heitzman et al. (1981) reported that animals implanted with REV in one ear grew faster than C and the other treatment groups to 98 d. Heitzman et al. (1981) concluded that the effects of estradiol and F appear to be independent and additive, unless administered as a combined implant form.

Looking at the effects of REV on heifers, Little et al. (1979) stated that there was little or no increase in ADG when heifers were implanted at 16 wk of age, but when implanted at 31 wk of age, there was a significant increase (21%) in ADG for the REV treatment group.

In three field trials with bulls, ADG was significantly higher in REV-treated bulls than in C (Grandadam et al., 1975). In an experiment examining bulls implanted with REV at three implant periods (0, 10 and 18 wk), Henricks et al. (1988) reported that treated bulls outgained C during the first period; however, growth rate of REV bulls was similar to C in the second and third implant periods.

Forplix (FOR) is an implant produced by International Mineral and Chemical Co.. It contains 140 mg of trenbolone acetate and 36 mg of zeranol. In an experiment with grazing steers, the response in ADG and final live weight to FOR was identical to that of F plus estradiol (200 g/d and 33 kg, respectively) over that of C steers (Keane, 1987). Roche et al. (1978) reported that either F or R alone increased ADG over C; however, the combination of the two implants gave a further significant increase in ADG. Griffiths (1982) found that ADG of FOR-implanted steers was significantly higher than that of C. Also, in a second experiment, FOR-implanted animals at two levels of feeding significantly improved ADG over C (Griffiths, 1982). Griffiths (1981) conducted two experiments with the dosage level of trenbolone acetate and zeranol in combination and concluded that ADG were increased with 600 mg of trenbolone acetate and 72 mg of zeranol over

C, but other dosage levels did not increase ADG.

Keane (1986) found that implant treatments of R alone, S alone and the combination of R plus F (F+R) significantly increased ADG over C at all periods from d 0 to slaughter; over non-implanted controls; however, there were no differences among implant treatments. This supported an earlier experiment which showed that over the first 70 d, estradiol plus F increased ADG by 32.4% compared with steers treated with estradiol alone; however, gains were similar to those of R+F-treated steers. Over the entire experimental period, there was no difference in ADG between estradiol X trenbolone acetate and F+R, either implanted once or twice; however, implantation increased gain by 11.1 and 12.5%, respectively, over C (Keane et al., 1985a). Brethour and Schanbacher (1983) showed that gains of steers implanted with FOR or REV were greater ( $P < .05$ ) than steers receiving R, C, F or S. FOR and REV groups averaged 22 and 26%, respectively, greater gains than non-implanted steers.

Silcox et al. (1986) conducted an experiment comparing F, R and FOR effects on growth rate of bulls and concluded that ADG did not differ among treatment groups. This contradicts the conclusions of Fabry et al. (1983) who found that ADG was significantly higher in FOR-treated bulls (1.34 kg/d) than untreated bulls (1.09 kg/d).

A combination of S + F in finishing steers produced the highest ADG when compared to COMP-implanted and C steers; however, there were no differences among the treatments of COMP + F, R + F and S + F (Keane, 1987). In an experiment comparing F+S and F+R, Keane and Sherington (1985b) reported that F+S increased ADG by 121 g/d when compared to steers implanted with F+R. Brethour (1986) indicated similar conclusions when he found that F+S implanted steers gained significantly faster than steers implanted with the combination of R + F. Furthermore, he reported that F+S was conspicuously superior to F alone, R alone and S alone. The result of F+S implantation was 26% faster gains than that of C.

When comparisons were made between hexoestrol and REV, Stollard and Jones (1980) found that both hexoestrol and REV-implanted steers had significantly higher gains than C. From

implanting to the intermediate weight period, ADG was highest for REV-treated steers, followed by hexoestrol-treated, then C steers. However, from the intermediate period to slaughter, the response to REV decreased slightly while that of hexoestrol showed an increase of 34% above C compared with a 31% for REV cattle. Fisher et al. (1986a) reported that ADG of R-treated bulls and steers was significantly higher than the pooled ADG for bulls and steers treated with F + hexoestrol or F + R.

Therefore, it has been found that implanting cattle with anabolic agents does, in fact, increase growth rate. Furthermore, there appears to be an additive effect on growth rate when trenbolone acetate is combined with an estrogen-like compound.

Feed Intake. Thonney (1987) reported that steers implanted with R had 9.0% greater dry matter intake (DMI) than C steers. Cole et al. (1984) reported that R-implanted steers tended to have greater DMI at 14, 28 and 56 d in the feedlot. Borger et al. (1973) reported that R-implanted steers on a 9.5% crude protein diet consumed 21.3% more feed than C; whereas C steers consumed 3.7 and 16.7% more feed, respectively, on 11.0 and 12.5% protein diets than R-steers. Furthermore, Sharp and Dyer (1971) reported that feed consumption was only slightly increased while the efficiency of nutrient utilization was greatly increased by R implantation of steers and heifers.

In experiments with S implants, Lomas (1983) and Dinius and Baile (1977) concluded that there were no significant differences in DMI between implanted and C steers. However, Rumsey (1978; 1982) showed that S-treated steers had 14 and 11% greater DMI than C in their respective studies. These findings are supported by those of a later study by Rumsey (1984), who reported that S-implanted steers had significantly increased DMI when compared to C.

Implantation of cull cows with F tended to result in higher DMI than in untreated cows (Garnsworthy et al., 1986). This agrees with the findings of Heitzman and Chan (1974), who stated that trenbolone acetate treated heifers consumed a total of 122 kg more hay than C.

Varying results have been reported when comparing combination implants containing trenbolone acetate. Galbraith and Watson (1978) found that steers implanted with F, hexoestrol,

or a combination of the two tended to have higher DMI than C steers; however, there were no differences in among implant groups. In two experiments conducted by Istasse et al. (1988), DMI of bulls treated with REV were not different from C. Steers implanted twice with trenbolone acetate and estradiol consumed less feed than steers implanted only once with trenbolone acetate (Trenkle, 1987). Loblely et al. (1987) reported that REV-treated steers consumed more feed than C steers simply because of their faster growth rates and heavier weights when diets were readjusted at 3 wk intervals.

Feed Efficiency. Holstein steers implanted with R had a 5% improved feed efficiency over C (Thonney, 1987). This finding supports those of Cole et al. (1984) and Cain et al. (1986), who both found that feed efficiency was improved by implanting steers with R. Cohen and Cooper (1983) reported that feed-to-gain ratios did not differ significantly between R-implanted and C steers. Borger et al. (1973) reported that feed efficiency was 4.2% greater for implanted versus C steers within the low-protein group; however, efficiency was 11.6 and 17.5%, respectively, greater for R-implanted versus C steers fed diets of 11 and 12.5% crude protein, respectively.

Implanting heifers once with R improved feed efficiency by 5.5% over C, while reimplanting heifers resulted in a non-significant 1.9% improvement (Simms et al., 1983). However, when Utley et al. (1976) compared R and Synovex-H implants in feedlot heifers, feed efficiencies were similar among C, R- and Synovex-H-implanted heifers.

Research into feed efficiency in R-implanted bulls has, for the most part, shown that R has no significant effects on feed efficiency (Ford and Gregory, 1983; Price et al., 1983; Gray et al., 1986). Kirk and Cooper (1983) reported that feed efficiency was improved in Friesian bulls but was unaffected in Holstein bulls implanted with R. However, Greathouse et al. (1983) reported that R-implanted bulls tended to consume less feed per kg gain (8.1% less) than C bulls.

Lomas (1983) found that S implants had no effect on feed efficiency of steers. However, Dinius and Baile (1977) reported that S-implanted steers had increased weight gains and similar feed intakes compared to C steers; thus, the feed-to-gain ratio was correspondingly improved. Rumsey

(1978; 1982; 1984) has shown that feed efficiency is improved as much as 11% in S-implanted steers.

When experimenting with the effects of F on the feed efficiency of heifers, Galbraith (1980) reported that F-treated heifers were 23% more efficient than C. Crouse et al. (1987) found that heifers implanted with F were only slightly more efficient, whereas Henricks et al. (1982) concluded that efficiency was not different between F-treated and C heifers. Contrary to these findings, Heitzman and Chan (1974) reported that C were more efficient converters of hay to gain than F-implanted heifers.

Efficiency of feed utilization was significantly improved in two steer studies, following implantation with trenbolone acetate (Galbraith 1982). Trenkle (1987) supported Galbraith's conclusion when he reported that implanting steers twice with trenbolone acetate displayed an improvement of 7.4% in feed efficiency when compared to C.

When the effects of F combinations on efficiency of gain were investigated, implanting once with trenbolone acetate combined with estradiol resulted in an average improvement in feed conversion of 12.1% over C (Trenkle, 1987). Galbraith et al. (1983) and Heitzman et al. (1981) both reported that REV significantly lowered feed-to-gain ratios when compared to C. Little et al. (1979) reported that feed conversion ratios were significantly lower in heifers implanted with trenbolone acetate plus estradiol at 16 and 31 weeks of age and in heifers implanted at 31 weeks of age with trenbolone acetate alone.

Steers implanted with F + hexoestrol had significantly lower (28%) feed-to-gain ratios than C (Galbraith and Coelho, 1978). Galbraith and Watson (1978) found that the combination of hexoestrol + F significantly improved feed efficiency, in steers, compared to C. Galbraith and Geraghty (1982) reported that steers treated with F + hexoestrol had significantly improved feed efficiencies (a reduction of 3.28 kg dmi/kg lwg) during the first 34 d on trial (adequate feed). There was no difference in feed efficiency during the 46 d restricted feed period; however, a gradual increase in dietary energy to an adequate level resulted in significantly greater efficiency when compared to C (Galbraith and Geraghty, 1982). Galbraith and Dempster (1979) compared dose



levels of hexoestrol in a combination implant containing trenbolone acetate and concluded that hexoestrol + F significantly improved feed efficiency compared with steers implanted with F only; however, there was no difference between F + 15, 30 or 45 mg of hexoestrol. Furthermore, Galbraith (1979b) reported that implanting bulls with the F + hexoestrol combination significantly reduced feed conversion ratios from 9.2, in C bulls, to 8.4 in treated bulls. In a study of FOR in bulls, Fabry et al. (1983) reported that feed efficiency was considerably reduced from 7.52, for C bulls, to 6.24 for FOR-implanted bulls.

Therefore, implanting cattle with anabolic agents has been shown to increase feed intake. However, the increase in feed consumption by implanted-cattle can be justified by the higher ADG which results in an improvement in feed efficiency.

Masculinity. Few reports are available that pertain to masculinity development of steers implanted with a single anabolic agent. However, Unruh et al. (1986a) found that masculinity scores relative to age, were significantly lower for R-implanted bulls than for C bulls.

Trenbolone acetate has been evaluated in combination with other implants, relative to its effects on masculinity traits of steers and bulls. Brethour (1986) found that F + S treatment produced obvious masculine traits in steers, including curly faces, broad heads, thick necks and prominent crests. Furthermore, he indicated that these traits were more prominent when steers were implanted with F beginning 200 d before slaughter than if the combination was used only for the last 60 d. Masculinity was especially evident when the F + S combination was used three times (Brethour, 1986). These observations support the work of Galbraith and Watson (1978), who found that implanting with F tended to cause thickening of the neck and increased shoulder development, thus giving a bull-like appearance to steers. Johnson and Dikeman (1988) reported that steers implanted with a combination of F + R tended to be less masculine than either F + R-implanted or control bulls.

Trenbolone acetate-combinations appear to increase steer carcass masculinity. Griffiths

(1982) reported that animals implanted with a combination of R + F had a significantly higher proportion of muscle in the forequarter than did C. Wood et al. (1986) reported that the effect of implanting steers with REV produced carcasses with heavier neck muscle weights, with the exception of the m. semispinalis capitis and m. splenius cervicis muscles. Therefore, implantation produced a bull-like muscle distribution in steers and increased muscle weight even further in bulls. In addition, Galbraith and Watson (1978) reported that REV-treated steers had slightly heavier hides when compared to C bulls. When studying R implantation of bulls, Unruh et al. (1986a) found that masculinity of the jump muscle and crest in implanted bulls was less at 13.8 months than in C; however, masculinity in the implanted bulls was comparable to the C at 15.7 months of age. Therefore, it appears that implanting steers with trenbolone acetate-combinations increases masculinity traits of steers, resulting in a bull-like muscle distribution. However, studies examining the effects of anabolic agents on masculinity of bulls are contradictory and more research should be conducted to further understand the interaction between anabolic agents and masculinity.

Animal Behavior. Dykeman et al. (1982) researched the effects of either testosterone, estradiol, dihydrotestosterone or sesame oil (control) injections on the behavior of steers. They found the greatest relative response to testosterone treatment was Flehmen-lip curls and attempted mounts. Furthermore, estradiol had a significantly greater stimulatory effect than testosterone on sniffs given and received, chin rests given and received, mounts, stands and head and body butts received when compared to controls. Also, they reported that dihydrotestosterone-treated steers were as active as testosterone-treated steers in mounts, body butts given, and head butts received.

Baker and Gonyou (1984) reported that both 36 mg and 72 mg of R implanted in bulls decreased the number of attempted mounts and head bunts; however, both implant programs resulted in an increase in the number of head bunts in castrated animals. Unruh et al. (1986a) found that from 12.0 to 13.8 months of age, R bulls had fewer encounters of passive bunting, mounting attempts, and facility rubbing and a lower activity score than C bulls. In Friesian bulls, R-implantation resulted in less libido, and lowered fertility (Kirk and Cooper, 1983). McKenzie

(1984) reported that bulls implanted with R, at birth, and every 60 d thereafter, had significantly improved behavior as measured by RYDER scores when compared to C bulls. On the other hand, Gregory and Ford (1983) and Price et al. (1983), reported that R implants did not affect aggressive behavior in yearling bulls.

Even though research into the effects of S, F, and combinations on steer and bull behavior is scarce, it can be concluded that anabolic agents cause steers to behave like bulls. Whereas, implanting bulls causes them to behave like steers, depending on when they were implanted.

#### CARCASS CHARACTERISTICS

Maturity. Vanderwert et al. (1985) found that R increased overall maturity over C and that male status X implant means indicated that R had greater negative maturity effects in steers than it did in bulls. This is supported by Prichard et al. (1984), who concluded that R implants increased both lean and overall maturity significantly when compared to untreated steers. Crouse et al. (1987) reported that maturity was unaffected in heifers implanted with trenbolone acetate when compared to C heifers.

Greathouse et al. (1983) reported higher scores for both skeletal and overall maturity which indicates that R-treated bulls were more mature physiologically than C bulls, even though the R-bulls were slaughtered at younger chronological ages. Vanderwert et al. (1984) compared R dosage levels and concluded that bulls implanted with 36 mg exhibited significantly less skeletal maturity than those implanted with 72 mg. Unruh et al. (1986a) also found that skeletal maturity was greater for R-treated bulls; however, they found that lean maturity was greater for C, resulting in no difference in final maturity between R and C bulls. This supports the results of Ford and Gregory (1983), who showed that final maturity score was not affected by R treatment of bulls. Other research has shown that implanting bulls with R, S, Synovex-H and COMP had no significant effects on skeletal, lean or overall maturity (Johnson et al., 1984; Johnson et al., 1986).

Marbling. Sharp and Dyer (1971) and Lane et al. (1986) found no significant effect on marbling due to R implantation. However, Vanderwert et al. (1985, 1986) showed that R

decreased marbling in bulls and steers when compared to C bulls and steers.

Lomas (1983) and Prior et al. (1978), both reported that S implantation had no effect on marbling. However, Brethour (1983) noted that the only effect of S implantation on carcass characteristics was a significant reduction in marbling. This supported the conclusions of Dinius and Baile (1977), who stated that marbling tended to be lower in S implanted steer carcasses. However, Rumsey (1982) reported that carcasses from steers implanted with S tended to have more marbling than carcasses of C steers.

Marbling did not differ between F or non-implanted heifers (Crouse et al., 1987). However, Trenkle (1987) reported that in carcasses from steers implanted with trenbolone acetate alone, marbling tended to be lower than in C, estradiol- or estradiol + F-implanted steers. Silcox et al. (1986) reported F-implanted bulls tended to have less marbling than R, R + F and C groups and this difference was approached significance. Furthermore, Brethour (1985, 1986) reported that marbling score was lowered when steers were implanted with F + S and F + R.

Marbling score was actually greater for R-implanted bulls than their C counterparts (Unruh et al., 1986a). Ford and Gregory (1983), Johnson et al. (1984), Jones et al. (1986) and Johnson et al. (1986) found no significant differences between C and R, S, Synovex-H or COMP implanted bulls.

Quality Grade. Sharp and Dyer (1971) found that R treatment of heifers resulted in improved carcass quality grades. However, Lane et al. (1986) and Simms et al. (1983) reported that heifers treated with R were not different from C heifers for USDA quality grades. Calkins and Clanton (1984) found that R-implanted bulls tended to have higher quality grades than C steers.

When comparing R and S treatments, Cain et al. (1984) reported that carcasses of steers implanted twice with S had fewer Choice carcasses than C. Furthermore, Dinius and Baile (1977), Prior et al. (1978) and Brethour (1983) found that quality grade was reduced by implanting steers with S. On the other hand, Rumsey (1982) reported that carcasses of S-implanted steers tended to have slightly higher quality grades than C steers. However, Dinius et al. (1978) and Lomas (1983)

reported that USDA quality grade was not affected by S implantation.

Trenkle (1987) reported that quality grades tended to be lower in carcasses from steers implanted with F alone, when compared to C. Mean quality grades were not different between heifers implanted with trenbolone acetate for 62 or 99 d, and C (Henricks et al., 1982). Moreover, Best (1972) showed that quality grade tended to improve when heifers were implanted with trenbolone acetate.

Johnson et al. (1986) found no differences among S, Synovex-H and R-treated or C bulls and steers for USDA quality grade. Brethour (1986) found a trend toward lowered quality grades when F + R and F + S were used.

Therefore, research indicates that implanting steers and heifers with implant combinations lowers both marbling and quality grade. Implanting bulls, on the other hand, has been shown to result in higher marbling scores, when compared to non-implanted bulls.

Lean Color. Prichard et al. (1984) stated that carcasses from heifers implanted with R had darker lean color than C heifers. DeVol et al. (1984) reported that R had no significant effect on total pigment concentration (evaluated on both a wet tissue and fat-free basis) or visual color score. Furthermore, Ford and Gregory (1983), Greathouse et al. (1983) and Vanderwert et al. (1984) reported lean color of bulls implanted with R to be similar to the color of C bulls. In one study, the lean color of R-treated bulls tended to be lighter than C (Unruh et al., 1986b). Jones et al. (1986) found that R-treated bulls had 24 h pH values well above 6.0 and resulted in a higher incidence of dark-cutting meat (13 of 18 carcasses) in bulls implanted with R at 3 mo of age, and 7 of 18 bulls implanted at 6 mo of age; however, they also reported that 4 of 18 C bulls and 2 of 18 C steers had dark lean.

Lean color did not vary among heifers implanted with F or C (Crouse et al., 1987). Johnson and Dikeman (1988), when studying bulls implanted with F + R, found that longissimus muscle color was very desirable for both treated and C bulls. Brethour (1986) reported that F + S produced dark-cutters in one trial consisting of steers; however, in subsequent trials, when steers

were slaughtered soon after arrival at the packing plant to reduce stress, no additional dark-cutters were observed.

Lean Texture. Crouse et al. (1987) stated that F treatment had no effect on the lean texture of heifers. Johnson and Dikeman (1988) reported that longissimus muscle texture was judged very desirable when bulls implanted with the combination of F + R were compared to C bulls. When experimenting with R effects in bulls, Unruh et al. (1986b) found that the lean texture of R-implanted bulls was not significantly different from C bulls. This supports the conclusions of Ford and Gregory (1983), who reported that lean texture scores were not affected in carcasses from R-implanted bulls.

Lean Firmness. Lean firmness was similar for C and R-treated bulls (Greathouse et al., 1983; Unruh et al., 1986b). Longissimus muscle firmness was very desirable for both F + R-treated and untreated bulls (Johnson and Dikeman, 1988). Finally, Crouse et al. (1987) reported that lean firmness in heifers implanted with F did not differ from C.

Dressing Percent and Carcass Weight. Lane et al. (1986) experimented with R-implanted heifers and found that R increased dressing percent compared to C.

When dressing percent was evaluated in R-implanted bulls, R had no affect on dressing percent (Ford and Gregory 1983). Researchers seem to be in agreement with the conclusion that R-implantation has little to no affect on dressing percent of bulls (Greathouse et al., 1983; Kirk and Cooper, 1983; Jones et al., 1986; Unruh et al., 1986a).

Cain et al. (1984) showed that steers implanted twice with S had higher dressing percents than C. This is in agreement with Rumsey (1982), who found that dressing percent was greater for S-implanted steers than for C steers. However, Dinius et al. (1978) revealed that S had no effect on dressing percent of steers.

In one of the first studies dealing with implantation of F, Best (1972) reported that there were no significant differences in the dressing percents of F-treated and C heifers.

Revalor has been shown to increase dressing percent of steers (Galbraith et al., 1981;

Stollard and Jones, 1980). However, Heitzman et al. (1981) reported that dressing percent of REV-treated steers was similar to that of C. When comparing the dressing percents of steers implanted with F + R, S or COMP, Keane (1987) and Keane et al. (1986) stated that there were no differences in dressing percents among treated and C steers. However, Griffiths (1982) reported that dressing percent was higher in F + R-implanted steers than in C steers. Generally, it appears that anabolic agents have little effect on dressing percent; however, when cattle are implanted with an androgenic-estrogenic combination, dressing percent appears to be improved.

If implants are generally thought to increase growth rate and subsequently final live weight, then it is appropriate to assume that treatment of cattle with anabolic agents would increase carcass weight. Cole et al. (1984) found that R-implanted steers had significantly heavier carcass weights than C. Calkins et al. (1986) reported that R- and COMP-implanted steers had heavier carcasses than C steers. When comparing R and S implants, Cain et al. (1984) showed that implanted steers had heavier hot carcass weights than C; however, there was no difference between R- and S-treated steers.

In heifers, R-treatment increased carcass weight over C (Lane et al., 1986). However, Simms et al. (1983) found that carcass weight was not significantly affected in R-treated heifers.

Implanting bulls with R generally has had no effect on carcass weight (Greathouse et al., 1983; Unruh et al., 1986a). Johnson et al. (1986) was in agreement when they concluded that there was no effect of R and S implants on carcass weights of bulls. However, Fisher et al. (1986), when comparing the effects of R, F + hexoestrol and sham implants, found carcass weights of R bulls were significantly heavier than the pooled weights from the F + hexoestrol and sham-implant treatments.

Carcass weights of F-treated heifers have been shown to be unaffected by treatment (Henricks et al., 1982). Furthermore, Heitzman et al. (1981) stated that F-implanted steers and those implanted with REV had heavier carcass weights than C steers. Galbraith et al. (1983) reported that REV-treated steers had significantly superior mean values for carcass weights than C.

When other F combinations were experimented with, carcass weight was highest in finished steers implanted with F + S compared to COMP-implanted and C steers; however, there were no differences among F + R, F + S and F + COMP combinations (Keane 1987). Furthermore, Keane and Sherington (1985b) reported that carcasses from steers given the combination of F + S were 6.7 kg heavier than those given F + R. Griffiths (1982) showed that F + R increased carcass weights of steers.

Fat Thickness. Most researchers agree that a measure of external fatness is the most important single factor affecting the cutability of beef carcasses. The effects of exogenous hormone implants on fat thickness have been conflicting to say the least.

Sharp and Dyer (1971) reported that R had no significant effect on fat thickness. Lane et al. (1986) and Simms et al. (1983), when experimenting with R, concluded that carcasses from implanted heifers had similar fat thicknesses to C. However, R-implanted bulls have been shown to have more subcutaneous fat than non-implanted bulls (Ford and Gregory, 1983; Greathouse et al., 1983; Vanderwert et al., 1984; Calkins et al., 1986; Unruh et al., 1986a).

Lomas (1983) and Prior et al. (1978) concluded that fat thickness of steers implanted with S was not affected. However, Johnson et al. (1986) demonstrated that S-treated bulls were significantly fatter than C bulls. Furthermore, when actual fat thickness opposite the LM was adjusted for variations in fatness in other areas of the carcass, carcasses from S bulls were fattest and carcasses of R and COMP bulls were leanest.

Trenkle (1987) reported that fat thickness was reduced in F-treated steers. However, Wood et al. (1986) reported that REV-treated steers were fatter than C steers and bulls, as well as having a higher subcutaneous to intermuscular fat ratio than C. Fisher et al. (1986b) also found that carcasses of REV bulls contained significantly higher proportions of both subcutaneous and intermuscular fat.

Longissimus Muscle Area. The area of the longissimus muscle has long been accepted as an indicator of carcass muscularity. Sharp and Dyer (1971) reported no significant difference in



loineye area due to R administration to steers. Raigro implantation of heifers, on the other hand, has been shown to increase loineye area when compared to C (Simms et al., 1983; Lane et al., 1986). As far as bulls are concerned, Greathouse et al. (1983) reported that loineye areas were not significantly different between R and C bulls. However, Kirk and Cooper (1983) found that loineye areas were significantly improved by implantation with R, being 87.2, 108.8, 67.9 and 82.7 cm<sup>2</sup> for C Friesian, R-treated Friesian, C Holstein, and R-treated Holstein bulls, respectively.

In a study by Lomas (1983), cattle implanted with S had significantly larger loineyes than C. Rumsey (1982) also found that carcasses of S steers tended to have greater loineyes than carcasses of C. However, Prior et al. (1978) reported that at a constant carcass weight, loineyes were not significantly changed by S implants. Furthermore, when comparing S and R treatments on bulls, loineyes of Synovex (H and S) and R treated bulls were similar to C.

Galbraith et al. (1981) reported that steers treated with REV had increased ribeyes compared to C. The conclusions of Trenkle (1987) are in agreement, since he found that F, estradiol and the combination of the two implants increased loineyes over C steers. For bulls, Fisher et al. (1986b) reported a tendency for REV to cause smaller loineye areas than C.

It can be concluded that loineyes are increased in steers and heifers implanted with an anabolic agent. However, when bulls were treated with anabolic growth promotants, loineyes were not affected and in one case, reduced.

Percentage of Internal Fat. The percentage of kidney, pelvic and heart (KPH%) fat is another key factor in the U.S.D.A. cutability equation, which has been shown to be affected by hormone treatment. Kercher et al. (1984) showed that KPH% was greater in R-treated than in S- or COMP-treated steers. However, Sharp and Dyer (1971) reported no significant effect on KPH fat in R-treated steers. Trenkle (1987) reported that KPH fat was reduced by F implantation of steers. Heitzman et al. (1981) reported that steers treated with REV and those treated with estradiol alone had significantly less omental and KPH fat than F-treated and C steers. Galbraith et al. (1983) and Keane and Sherington (1985b) reported that KPH fat of steers treated with REV

or a combination of F and R were similar to C.

When bulls were implanted with R, there was a tendency towards higher KPH% fat when compared to C (Greathouse et al., 1983). Moreover, Silcox et al. (1986) found that bulls implanted with F + R had significantly more KPH fat than bulls implanted with either R or F and C. Johnson et al. (1986) showed that S-implanted bulls were similar in KPH% fat to R and C bulls.

USDA Yield Grade. USDA yield grade is one of the primary methods by which cattle are classified and is a measure of the percentage of closely trimmed retail cuts from the round, loin, rib and chuck. Sharp and Dyer (1971) reported that R implantation had no effect on yield grade of steer carcasses. Furthermore, Cain et al. (1984) found similar yield grades for carcasses from steers implanted with R or S and C.

Prichard et al. (1984) and Lane et al. (1986) both found that heifers implanted with R had lower numerical yield grades than C heifers.

In experiments with R-implanted bulls, Unruh et al. (1986a) reported that USDA yield grade tended to be higher for R bulls than for C. Greathouse et al. (1983) was in agreement when they found numerical yield grade tended to be higher for R-implanted bulls. Furthermore, in a study comparing R and COMP treatment on bulls, Calkins et al. (1986) noted that C bulls had lower numerical yield grades than either R- or COMP-treated bulls. Finally, Silcox et al. (1986) reported that R bulls had significantly lower USDA yield grades than C; however, both treatments resulted in very desirable yield grades (1's and 2's).

Lomas (1983) reported that S-treated steers had lower numerical yield grades than C. However, Dinius et al. (1978) and Prior et al. (1978) found that S-treated steers had yield grades similar to C. Johnson et al. (1986) found that S bulls had higher numerical yield grades than C and R-implanted bulls.

Heifers implanted with F for 62 and 99 d were not different from C heifers in carcass cutability (Henricks et al., 1982). When steers were implanted with F + R, Griffiths (1981, 1982) reported that carcasses of treated steers had significantly more lean meat and significantly less

trimmable fat than C carcasses.

Carcass Conformation. Carcass conformation is a subjective score of carcass shape, primarily influenced by muscling, and is a key factor by which many countries determine carcass value. Galbraith and Watson (1978) found that carcass conformation of steers treated with hexoestrol, F, or a combination of the two, were not adversely affected. However, conformation was shown to be improved in carcasses of steers implanted with F + COMP, F + R, and F + S (Keane 1987). Furthermore, Keane and Sherington (1985b) reported that conformation was increased by implantation with a combination of F + R when compared with C steers.

These studies show, with some exceptions, that anabolic implants produce steer carcasses with lower numerical yield grades than non-implanted steers. However, implanting bulls appears to reduce carcass cutability. Also, implantation of cattle with anabolic agents has been shown to improve carcass conformation over controls.

Fat Score. A subjective measurement of a carcass fatness is used in many European countries. Keane (1987) noted that combination treatments of F + COMP, F + R and F + S had no significant effects on fat score when compared to C steers. Also, Keane et al. (1986) and Keane and Sherington (1985a) reported that fat score was not significantly affected in steer carcasses by implantation with S, R or F + R. Furthermore, Galbraith and Watson (1978) reported that subjective fat score was unaffected by treatment of steers with F, hexoestrol or the F-hexoestrol combination. Therefore, anabolic implants have been shown to have no effect on fat score of steers.

Composition. Longissimus muscle from R-implanted steers contained significantly more moisture, less fat and equal amounts of protein on either a fat- or moisture-free basis than that of C (Borger et al., 1973). However, Smithson et al. (1973) stated that DES, testosterone, R, S or DES plus testosterone treatments did not alter carcass composition.

Crouse et al. (1987) reported that heifers treated with F tended to possess less fat cover and less fat in the soft tissue of the 9-10-11th rib section than C. When steers were implanted with F + R, the edible portion of carcasses contained significantly more water and protein as well as less

fat (Griffiths 1981; 1982).

Implanting bulls with R increased the percentage of lipid in rib-section and carcass to the level of steers (Calkins and Clanton, 1984). Furthermore, in a study comparing bulls implanted twice with 36 mg of R, once with 72 mg of R, castrated at 1 yr of age and untreated bulls, Gregory et al. (1983) found that bulls implanted with R generally did not differ in carcass composition from each other and from C bulls; however, implanted bulls had a higher percent of fat in the LM than C bulls. On the other hand, Greathouse et al. (1983) reported that carcasses of C bulls tended to have a higher percentage of moisture and a lower percentage of lipid than R-implanted bull carcasses. Johnson et al. (1986) found R-treated bulls had a lower marbling score than S-treated bulls. Fat and moisture percentages of C, R and Synovex-H bulls were not different, while the S bulls had more fat and less water than the other three treatment groups (Johnson et al., 1986).

Therefore, it can be concluded that implanting steers with anabolic agents has no effect on protein content of the 9-10-11th rib section, with the exception of the studies concerning the F + R combination implant which increase both moisture and protein in steer carcasses. Implanting bulls postweaning has been shown to decrease lipid and increase moisture over non-implanted bulls.

#### EFFECTS OF ANABOLIC AGENTS ON BEEF PALATABILITY

Tenderness. Vanderwert et al. (1986) evaluated the effect of R implantation of steers and bulls on meat quality and reported that R tended to increase Warner-Bratzler shear (WBS) force values for the semimembranosus and LM. However, they did not find any significant differences in WBS values among treatments for either the semitendinosus, adductor or biceps femoris. Calkins et al. (1986) reported equal tenderness between steaks from R- and COMP-implanted steers and bulls. On the other hand, Unruh et al. (1986b) found that R-treated bulls tended to have lower LM WBS values than C.

Smithson et al. (1973) found no differences in tenderness among steaks from steers subjected to DES, testosterone, R, S, and DES + testosterone implant treatments. This finding is

in agreement with that of Borger et al. (1973a), who reported identical mean sensory panel scores for tenderness between R-treated and C steers. However, Calkins et al. (1986) reported that steaks from R-treated steers were less tender than steaks from C.

Pelton et al. (1984) indicated that bulls implanted with R from weaning to slaughter had the least desirable sensory panel tenderness values. In addition, steers and bulls implanted with R from birth to slaughter were rated more tender than those implanted only preweaning or only postweaning. Unruh et al. (1986b) reported that sensory panel myofibrillar and overall tenderness were greater for steaks from R bulls at 12.0 and 13.8 mo of age than C bulls at 13.8 and 17.4 mo. Other workers have found no difference between R-treated bulls and untreated bulls for taste panel tenderness (Calkins et al., 1986; Greathouse et al., 1983; Gregory et al., 1983; Vanderwert et al., 1984; Johnson et al., 1986); however, most of these researchers did not implant until weaning or later. Thus, the effect of R on tenderness of beef remains unclear.

Synovex-S treated bulls and steers yielded steaks that were comparable in tenderness to their respective untreated counterparts; however, treated steers tended to receive higher scores for tenderness than treated bulls (Forrest, 1975). Johnson et al. (1984) also found no significant difference in panel-evaluated tenderness when S-treated bulls were compared to untreated, R- and COMP-treated bulls. However, Stout et al. (1981) reported C steers and heifers were rated more tender by a sensory panel than S-implanted steers and heifers. They reported that S-implanted bulls were more tender than their non-implanted C.

Tenderness scores and WBS values for F-treated heifers were very similar to those of C heifers (Crouse et al., 1987). In a study comparing F + R-implanted and non-implanted bulls and steers, Johnson and Dikeman (1988) reported that implanting bulls and steers had no significant effects on either myofibrillar, overall tenderness, or WBS force. When veal calves were subjected to implantation with REV and FOR, van Weerden (1984) reported neither treatment had any effect on cooked LM WBS values. However, sensory panel ratings of LM tenderness were significantly higher for C than for the REV-treated veal calves.

Muscle connective tissue can have a profound affect on meat tenderness. Calkins et al. (1986) found no differences in connective tissue content between R- and COMP-implanted bulls and steers, and C as perceived by the sensory panel. In addition, total and percent soluble collagen were not different for either R, COMP or C bulls and steers. Unruh et al. (1986b) found that R-implanted bulls had less total collagen, thus resulting in less heat-labile (soluble) collagen and less insoluble collagen than C bulls. Futhermore, they reported that heat-labile (soluble) collagen was significantly lower for R bulls at 12.0 and 13.8 mo of age than C bulls, whereas treated bulls were similar to C bulls at 15.7 and 17.4 mo. (Unruh et al., 1986b). These observations agree with those of Greathouse et al. (1983), who stated that implanting with R decreased sensory panel detectable connective tissue in steaks from bulls.

Stout et al. (1981) reported that S treatment of bulls tended to increase sensory-panel detectable-connective tissue. However, Crouse et al. (1987) reported that sensory-panel connective-tissue scores for steaks from F-treated heifers were similar to steaks from C heifers. Connective-tissue amount tended to be higher for C bulls when compared to either bulls or steers implanted with a combination of F + R (Johnson and Dikeman, 1988).

Flavor, Juiciness and Overall Acceptability. Borger et al. (1973) reported no significant differences for juiciness, flavor or overall acceptability between R-treated steers and C. Smithson et al. (1973) also found no significant differences in palatability of beef among DES, testosterone, R, S or DES + testosterone treatments and C.

Bulls implanted with R from birth to slaughter had significantly higher sensory panel juiciness and overall acceptability values when compared to C bulls (Pelton et al., 1984). Calkins et al. (1986) found that R-implanted bulls produced steaks that were juicier than the leaner steaks from C bulls. Unruh et al. (1986b) reported that flavor intensity and juiciness scores were similar for both R and C bulls, which agrees with the reports by Greathouse et al. (1983), Gregory et al. (1983) and Vanderwert et al. (1984) who found no differences in flavor, juiciness or overall acceptability between R-implanted bulls and C bulls.

Stout et al. (1981) reported that C steers and heifers produced steaks that tended to be juicer and more desirable than S-treated heifers, whereas, bulls implanted with S had significantly higher juiciness and overall desirability scores than non-implanted bulls. Contrary to these findings, Johnson et al. (1984) and Johnson et al. (1986) found no differences in taste panel scores among Synovex-H, S- and R-implanted bulls. Johnson and Dikeman (1988) concluded that there was no significant effect of F + R implantation on flavor intensity in steaks from bulls.

### MECHANISMS OF ACTION OF ANABOLIC AGENTS

Androgens. Androgens are generally thought to be anabolic in nature, thus promoting protein synthesis. Androgenic agents have been shown to increase carcass protein content of cattle (Muir, 1985) by stimulation of muscle protein synthesis. Young (1985) noted that administration of testosterone derivatives to castrated animals increased ribosome activity, increased RNA polymerase activity and elevated ribosome content, all of which support the hypothesis of increased protein synthesis. However, trenbolone acetate, a synthetic androgenic agent, has been shown to reduce the rate of muscle protein synthesis and degradation, but the reduction in rate of degradation must be greater than the rate of synthesis so that the net effect is an increase in protein accretion (Buttery et al., 1978).

At present there are two primary schools of thought on the mechanisms of action of testosterone and androgenic derivatives. The first hypothesis implies direct action on the muscle. Buttery and Sinnett-Smith (1984) stated that in some reproductive tissues, testosterone is a pre-hormone which must first be reduced to dihydrotestosterone which is then bound by androgenic receptors. The hormone diffuses into the cytoplasm of the target cell and then concentrates in the nucleus where the dihydrotestosterone-receptor complex interacts with an acceptor, possibly a protein in the chromatin, and triggers a response (Michel and Baulieu, 1983). These authors, also showed that methyltrenbolone, a synthetic form of testosterone, had an affinity for the receptor, which is very similar to that of testosterone. This evidence suggests that trenbolone acetate binds

to the same receptor and reacts in a manner similar to testosterone.

Muir (1985) postulated that androgenic agents compete for, or "down regulate" muscle glucocorticoid receptors, and thereby reduce the catabolic effects of glucocorticoids on muscle protein metabolism. This view assumes that androgens are anticatabolic rather than anabolic in nature. Research has shown that circulating cortisol concentrations are reduced by trenbolone acetate treatment of sheep and rats (Buttery and Sinnett-Smith, 1984). However, Florini (1985) stated that, in addition to the direct evidence for testosterone receptors in muscle, two other lines of evidence refute the anticatabolic action of testosterone; 1) separate androgen and glucocorticoid receptors have been found in muscle cytosol and 2) it has been demonstrated that testosterone is anabolic in adrenalectomized rats. Despite these findings, there is other evidence that supports the involvement of glucocorticoid status in trenbolone acetate action. Buttery and Sinnett-Smith (1984) reported that trenbolone acetate reduced female rat liver tyrosine transaminase (an enzyme induced by glucocorticoids that is involved in muscle protein turnover) activity. On the other hand, in studies using male rats treated with trenbolone acetate, Buttery and Sinnett-Smith (1984) reported little change in the activity of tyrosine transaminase was noted. Also, they reported that the treated male rats showed no increase in growth rate over the nontreated male rats in this study.

It is clear that more investigations into the mode of action of testosterone and androgenic derivatives are needed to determine the mechanisms whereby muscle protein synthesis, and ultimately animal growth, are affected.

Estrogens. Estrogenic agents are the major class of growth promotants currently being used for ruminants. Diethylstilbestrol, a synthetic estrogen, was the first widely used growth promotant and the first implant to improve gain of heifers (Dinussou et al., 1948). Although diethylstilbestrol is no longer approved for use in red meat production, other estrogenic agents, as well as synthetic anabolic agents are available (Table 1 and Table 2). The major effect of estrogenic agents on ruminants is to increase carcass protein content (Muir, 1985). The mechanisms through which estrogenic agents promote growth, however, are not clear.



As with androgenic agents, there are several thoughts on the mode of action of estrogenic agents on protein synthesis of ruminants. The first theory is that estrogenic agents may act directly on muscle cell protein synthesis. Michel and Baulieu (1983) reported that certain authors claim that estrogen receptors, which are different from androgen receptors, exist in muscle. However, Michel and Baulieu (1983) found that estradiol binds to androgen receptors and may have an identical effect to that of androgens on protein synthesis. Florini (1985) reported that injection of estradiol in rats gave a substantial reduced glucose-6-phosphate dehydrogenase activity. Furthermore, Florini (1985) pointed out that there was a general correlation between glucose-6-phosphate dehydrogenase levels and muscle development/or regeneration. Therefore, he concluded that the presence of estrogen receptors in muscle, and the prevention of glucose-6-phosphate dehydrogenase activity by injection of estrogen antagonists suggests that the action may, in fact, be direct.

A second theory is that estrogens have direct actions on some other tissues besides muscle. The most consistent change noted in cattle and sheep treated with estrogenic agents has been an increase in weight of the anterior pituitary gland (Trenkle, 1983). Furthermore, Trenkle reported that the mean growth hormone concentration in blood plasma is increased following treatment with estrogens and testosterone propionate, but not with trenbolone acetate. Trenkle, therefore, proposed that the increased pituitary size and release of growth hormone may be caused by increased release of the hypothalamic growth-hormone-releasing factor or that estrogens might be modulating receptors on the pituitary cells, thus increasing the sensitivity of the gland to endogenous releasing factors. On the other hand, in ewe lambs implanted with zeranol, data indicate that there was a reduction in muscle-protein synthesis (Buttery and Sinnett-Smith, 1984) and it was concluded that if growth hormone was responsible for the action of zeranol, then protein synthesis would be expected to be elevated.

Finally, it has been suggested that an increase in insulin might be responsible for the anabolic action of estrogenic agents by stimulating protein synthesis (Muir, 1985). Muir reported, however, that elevated insulin levels, in addition to causing protein synthesis, would be expected to

TABLE 1. NATURAL HORMONES AVAILABLE FOR USE AS ANABOLIC AGENTS IN BEEF PRODUCTION

Trade Name	Chemical Contents	Dosage	Company	Used In	Withdrawal Time
Compudose	Estradiol-17 $\beta$	24 mg	Elanco	Steers Heifers Calves	NONE
Synovex-S	Progesterone Estradiol Benzoate	200 mg 20 mg	Syntex	Steers	NONE
Torevex-S <sup>a</sup>	(same as Synovex-S)		Channelle	Steers	NONE
M-PO <sup>a</sup>	(same as Synovex-S)		Ireland	Steers	NONE
Steer-oid	(same as Synovex-S)		Anchor Labs	Steers	NONE
Synovex-H	Testosterone Propionate Estradiol Benzoate	200 mg 20 mg	Syntex	Heifers	NONE
Torevex-H <sup>a</sup>	(same as Synovex-H)		Channelle	Heifers	NONE
F-TO <sup>a</sup>	(same as Synovex-H)		Ireland	Heifers	NONE
Heifer-oid	(same as Synovex-H)		Anchor Labs	Heifers	NONE
Synovex-C	Progesterone Estradiol Benzoate	100 mg 10 mg	Syntex	Calves	NONE

<sup>a</sup>Anabolic agents that are not approved for use in the United States, but are used elsewhere.

TABLE 2. SYNTHETIC HORMONES AVAILABLE FOR USE AS ANABOLIC AGENTS IN BEEF PRODUCTION

Trade Name	Chemical Components	Dosage	Company	Withdrawal Used In	
Finaplix-S	Trenbolone Acetate	140 mg	Hoechst-Roussel	Steers	NONE
Finaplix-H	Trenbolone Acetate	200 mg	Hoechst-Roussel	Heifers	NONE
Ralgro	Zeranol	36 mg	IMC, Co.	Steers Heifers Calves	NONE
MGA	Melengestrol Acetate	.2-.5mg	Upjohn	Heifers	48 Hours
Forplix <sup>a</sup>	Trenbolone Acetate Zeranol	140 mg 36 mg	IMC, Co.	Steers	Unknown
Revalor <sub>L</sub> <sup>a</sup> Revalor <sub>C</sub> <sup>a</sup>	Trenbolone Acetate Estradiol-17 $\beta$	140 mg 20 mg	Hoechst-Roussel	Steers	Unknown
Torelor <sub>C</sub> <sup>a</sup>	Trenbolone Acetate Estradiol-17 $\beta$	200 mg 40 mg	Hoechst-Roussel	Steers	Unknown

<sup>a</sup>Anabolic agents that are not approved for use in the United States, but are used elsewhere.

cause enhanced lipogenesis. Possibly, the effect of estrogenic agents on insulin secretion may be indirectly caused by diabetogenic effects of elevated growth hormone concentrations that would favor protein synthesis over lipogenesis (Trenkle, 1983).

In conclusion, it has been difficult for researchers to provide a widely acceptable hypothesis for the mode of action of anabolic steroid agents. Therefore, more research is needed to develop a more concise understanding of how exogenous hormones affect muscle growth.

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## CHAPTER III

EFFECTS OF FINAPLIX®, SYNOVEX-S® AND RALGRO® IMPLANTS,  
SINGULARLY OR IN COMBINATIONS, ON PERFORMANCE,  
CARCASS TRAITS AND LONGISSIMUS PALATABILITY OF  
HOLSTEIN STEERS

## ABSTRACT

Seventy-two holstein steers averaging 182 kg were used to evaluate the following implant treatments: (1) non-implanted control (C); (2) implanted with Ralgro® (R); (3) implanted with Synovex-S® (S); (4) implanted with Finaplix (F); (5) implanted with Finaplix® and Synovex-S (F+S) and (6) implanted with Finaplix and Ralgro (F+R). Each treatment group consisted of three replications of 4 animals/pen, which were reimplanted on d 56, 112 and 168. Steers were stepped up to a finishing diet and fed to consumption twice daily. Masculinity and muscling scores were assigned at 24 h pre-slaughter. Hide removal difficulty was scored by a plant supervisor. Quality and yield grade data were obtained at 24 h postmortem. Longissimus muscle (LM) steaks were removed and cooked for Warner-Bratzler shear (WBS) determinations and sensory panel (SP) evaluations. Over the entire feeding period (249 d), F+S steers had higher ( $P < .05$ ) ADG than F+R, F and C steers. All treatments had higher ( $P < .05$ ) ADG than C, with the exception of F. The only feed efficiency differences were during the fourth implant period, when F steers were more ( $P < .05$ ) efficient than F+R or C steers. The F+S and F+R steers had higher ( $P < .05$ ) masculinity and hide pull scores than S and C steers. Carcass weights of F+S steers were heavier ( $P < .05$ ) than those of F or C steers. The F+S steers had larger ( $P < .05$ ) LMA than R, F and C groups. Also, F+S steers tended ( $P = .07$ ) to have lower yield grades than S, R or C steers. Even though mean marbling scores and quality grades were similar ( $P > .05$ ) among treatment groups, only 50% of F+S carcasses graded low Choice or better compared to 100, 75, 82, 90 and 83% for C, F, R, S and F+R carcasses, respectively. The only meat palatability differences were that myofibrillar and overall tenderness scores were lower ( $P < .07$ ) for steaks from S and F+R than from R and C groups.

(Key words: Implants, Average Daily Gain, Carcass Traits, Feed Efficiency, Holsteins, Meat Palatability).

## INTRODUCTION

The demand for lean beef and a surplus of Holstein steers has fueled renewed interest in the Holstein breed as a lean-beef producing breed. Holsteins have been shown to gain at equal or faster rates when compared to typical beef breeds (Cole et al., 1963; Garcia-de-Siles et al., 1977; Young et al., 1978; Newland et al., 1979; Thonney et al., 1981; Thonney, 1987).

A definite advantage in rearing Holstein steers for beef production is that Holstein carcasses have less external fat than most beef breeds (Cole et al., 1963; Charles and Johnson, 1976; Young et al., 1978; Newland et al., 1979; Nour et al., 1981, 1983; Bertrand et al., 1983). Furthermore, Holstein carcasses are superior in USDA yield grade when compared to some beef breeds (Cole et al., 1963; Young et al., 1978; Bertrand et al., 1983; Nour et al., 1983). A major disadvantage of the Holstein breed is their low muscle-to-bone ratio, as measured either by longissimus muscle area or carcass conformation, when compared to beef breeds (Cole et al., 1963; Wellington, 1971; Garcia-de-Siles et al., 1977; Young et al., 1978; Nour et al., 1983).

Steaks from Holstein cattle have been found to be superior to, or comparable to steaks from beef breeds for longissimus muscle palatability characteristics (Cole et al., 1963; Ziegler et al., 1971; Garcia-de-Siles et al., 1977; Lalande et al., 1982).

Finaplix, an implant containing the androgenic, anabolic-steroid trenbolone acetate, has been shown to increase growth rate in steers (Roche et al., 1978; Brethour, 1986; Trenkle, 1987). Moreover, when Finaplix is administered in combination with an estrogenic anabolic agent, growth rate is enhanced even more (Galbraith and Coelho, 1978; Galbraith and Watson, 1978; Galbraith and Dempster, 1979; Heitzman et al., 1981; Brethour and Schanbacher, 1983; Keane and Sherington, 1985a,b; Brethour, 1985, 1986; Keane et al., 1986; Silcox et al., 1986; Unruh, 1986; Keane, 1987; Trenkle, 1987).

In general, anabolic agents have been shown to reduce fat thickness, percent internal fat, USDA yield grade, marbling and USDA quality grade, while increasing carcass weight and



carcass conformation. Also, it has been reported that anabolic implants increase longissimus muscle area (Galbraith et al., 1981; Rumsey, 1982; Lomas, 1983; Trenkle, 1987).

Because of the low muscle-to-bone ratio of Holstein steers and the reports that anabolic agents may increase muscle mass, Holstein steers would benefit the most from implantation. Furthermore, the effects of anabolic agents and androgenic-estrogenic combinations on steer longissimus muscle palatability are unknown. Therefore, the objectives of our study were to determine the effects of implanting Holstein steers with Finaplix<sup>®</sup>, Ralgro<sup>®</sup> and Synovex-S<sup>®</sup>, as well as combinations of Finaplix plus Ralgro and Finaplix plus Synovex-S, on (1) live animal performance, masculinity and ease of hide removal; (2) carcass conformation and LM area; and (3) longissimus meat palatability.

## MATERIALS AND METHODS

Management. Seventy-two Holstein steers (3 to 5 mo of age) were weighed and allotted to pens of four animals with an average weight of 182 kg. Steers were allotted so that the variation and average weight among pens was similar. Five days later, after animals were acclimated, pens of four steers were assigned randomly to one of six treatments: (1) nonimplanted controls (C); (2) implanted with 36 mg zeranol (Ralgro®) (R) in the right ear; (3) implanted with 200 mg progesterone plus 20 mg estradiol benzoate (Synovex-S®) (S) in the right ear; (4) implanted with 140 mg trenbolone acetate (Finaplix®) (F) in the left ear; (5) implanted with R in the right ear and F in the left ear (F+R) and (6) implanted with S in the right ear and F in the left ear (F+S). Each treatment group consisted of three pens (replications) of steers which were reimplanted on days 56, 112 and 168 of the feeding trial.

Steers were fed increasing proportions of concentrate for 77 d (six diets) until the final diet which consisted primarily of sorghum silage and rolled milo (Table 3). Steers were fed to consumption twice daily in partially covered, concrete-floor pens for a total of 249 d. Individual weights were recorded at 28 d intervals after steers had been withheld from feed and water for approximately 14 h. Weights of diet fed to each pen were recorded daily. At each weigh period and diet change the remaining feed in the bunks was weighed back.

Two steers died and one steer was removed from feed, and subsequently died, during this trial. Metabolic weights were calculated and the amount of feed that the dead steers consumed was subtracted from their respective pen's total feed consumption. Two of the steers that died were implanted with S while the other steer was implanted with R.

Pre-Slaughter Evaluations. Twenty-four hours before slaughter, calves were weighed for the final time. A three person panel individually evaluated steers for masculinity and hindquarter muscling. Masculinity was scored on a scale from 1 to 5 (1=steer and 5=very masculine) and hindquarter muscling was scored on a scale from 1 to 10



(1=extremely thin and 10=extremely thick).

Slaughter Measurements. Upon arrival at Excel, Corp. packing plant in Dodge City, Kansas, cattle were grouped together for approximately 3 h before slaughter. Cattle were subjected to high-voltage electrical stimulation during the slaughter process.

At the point of hide removal, the supervisor in charge of the hidepulling station scored the degree of difficulty of hide pull on a scale from 1 to 5 (1=easy and 5=extremely difficult).

USDA quality and yield grade data were obtained at 24 h postmortem. Lean color, firmness and degree of heat ring formation were evaluated by a Kansas State University expert. Lean color was scored using the 8-point New Mexico State University standards for fresh beef color (1=bleached red and 8=very dark red). Firmness was scored on a scale of 1 to 7 (1=very firm and 7=extremely soft) and heat ring incidence was scored on a scale of 1 to 5 (1=none and 5=extremely severe). Hindquarter muscling was evaluated using the scale previously described in the pre-slaughter evaluation section.

At 28 h postmortem, National Association of Meat Purveyors specifications (NAMP, 1988) 107-oven prepared ribs were removed and shipped to the Kansas State University Meats Laboratory (one rib was lost in the packing plant, so only 68 ribs were received), and subsequently aged until 6 d postmortem. Beginning at the most posterior end of the rib, 2.54 cm thick longissimus muscle (**LM**) steaks were removed for sensory panel (**SP**) evaluations and Warner-Bratzler shear (**WBS**) force determinations. Each steak was wrapped in commercial freezer paper and frozen at -20 C until the time of evaluation.

Warner-Bratzler Shear Force Determinations. The WBS steaks were thawed for 16 h at 4 C and cooked in a Blodgett dual-air- flow oven to an internal temperature of 70 C (AMSA, 1978), monitored with thermocouples attached to a DORIC Minitrend 205 temperature monitor. After a 2 h cooling period at room temperature, eight 1.27 cm diameter cores were removed with a mechanical coring device perpendicular to the steak's cut surface and sheared through the center with a WBS device attached to an Instron 4201 (see Appendix V).

Sensory-Panel Evaluation. One steak was selected randomly from each treatment and thawed for 16 h at 4 C and cooked according to the procedure outlined for WBS. Cores (1.27 cm in diameter) were removed with a mechanical-coring device perpendicular to the steak's surface and served warm to a six-member, trained-sensory panel (SP) (AMSA, 1978). Evaluations for flavor intensity, juiciness, myofibrillar tenderness, connective tissue amount, overall tenderness and off-flavor intensity were made using scores of 1 to 8 (1=extremely bland, extremely dry, extremely tough, abundant amount of connective tissue, extremely tough overall or extremely intense off flavor; 8=extremely intense flavor, extremely juicy, extremely tender, no detectable connective tissue, extremely tender overall or no off flavors) (Appendix III).

Statistical Analyses. Because of uneven sample size, all data were analyzed using the general-linear-model procedure of SAS (SAS, 1985). Main effects considered in the model for performance, live evaluations and carcass characteristics included treatment and pen effects. Panelists and panelists X treatments were considered in the model for sensory panel evaluations. The pen within treatment mean square was used to test for differences between treatments. Least-squares means procedure were used to identify statistically significant ( $P < .05$ ) differences between treatment groups.

## RESULTS AND DISCUSSION

Animal Performance. Average daily gains (ADG, kg/d) for each of the treatment groups at specified weight and implant periods are reported in Table 4. At both 56 and 112 d, all implant treatments had higher ( $P < .05$ ) ADG than controls; at 56 d, there were no differences among implant treatments; however, at 112 d, the F+S group had higher ( $P < .05$ ) ADG than the F, R and S groups. Again at 168 d, the F+S group had higher ( $P < .05$ ) ADG than C, F, R and S groups, and all treatment groups, except F, gained faster ( $P < .05$ ) than C. The ADG of F+S and F+R implanted steers was similar ( $P > .05$ ) at 168 d.

For 205 d on feed, F+S steers gained faster ( $P < .05$ ) than F, R, S and C steers, but gains were similar ( $P > .05$ ) to the F+R steers. The C group gained less ( $P < .05$ ) than all implant groups. Over the entire feeding period (249 d), the F+S group had higher ( $P < .05$ ) ADG than F+R, F and C groups; the C group gained slower ( $P < .05$ ) than all groups with the exception of the F group.

The first implant period is the same as the first specified weight period (56 d from initial implantation to the second implantation). During the second implant period (from 56 to 112 d), F+S steers gained faster ( $P < .05$ ) than F, R and C steers, but not S and F+R steers. The S and F+R steers also gained faster ( $P < .05$ ) than C steers. There were no significant ( $P > .05$ ) differences observed in ADG among treatment groups during the third and fourth implant periods. Because steers were close to their target-weight endpoint and Ralgro was not yet approved for 0 d withdrawal, we did not reimplant any treatment group at d 224. This could have reduced the growth stimulating effects of some of our implant treatments.

These results agree with those of numerous researchers who have reported that F in combination with an estrogenic implant improves ADG when compared to singular implants or non-implanted C (Heitzman et al., 1977, 1981; Galbraith and Coelho, 1978; Roche et al., 1978; Stollard and Jones, 1980; Galbraith and Geraghty, 1982; Griffiths, 1982; Keane and Sherington, 1985a; Lobley et al., 1985; Fisher et al., 1986b; Keane et al., 1986; Henricks et al., 1988).

Brethour (1985) found that steers treated with the combination of F+S gained more than F, R, S and F+R treated steers, and gained 26% faster than C. Furthermore, Keane (1987) found that F+S steers had higher ADG's than Compudose-treated and untreated steers; however, there was no difference between F+S and F+R treated steers. Also, Keane and Sherington (1985b) reported that F+S, when compared to F+R, increased ADG by 10% for the first 71 d on feed; however, from 71 d to 149 d, there was no difference in ADG.

Feed intake data, figured both on a dry matter and an as-fed basis, are presented in Table 5. There were no significant ( $P>.05$ ) differences in either dry matter or as-fed intake for any weight period. However, differences among treatment groups were evident in the second, third and fourth implant periods. During the second implant period, S, F, R and C consumed less ( $P<.05$ ) dry matter than F+R steers and C, F and R steers consumed less feed than F+S steers. The F+R and F+S steers consumed similar ( $P>.05$ ) amounts of dry matter per day. For the third implant period, F steers consumed less ( $P<.05$ ) dry matter than R, S, F+S and F+R steers; however, there was no difference between F and C steers. In addition, C steers consumed less ( $P<.05$ ) dry matter than F+S and F+R steers. During the fourth implant period, F and C steers consumed less ( $P<.05$ ) dry matter than S, F+S and F+R steers. There were no differences ( $P>.05$ ) among R, S, F+S and F+R treatments.

When consumption was calculated on an as-fed basis, the results were similar to those made using dry matter feed weights, with one exception. During the second implant period, there were no differences ( $P>.05$ ) among C, F, R or S steers; however, these steers consumed less ( $P<.05$ ) as-fed feed than the F+R treatment group. As-fed feed intake was similar ( $P>.05$ ) for F+S and F+R treated steers.

Our results support the findings of Rumsey (1978; 1982) and Rumsey et al. (1984) reported that steers implanted with S had higher dry-matter intakes than C steers. However, other researchers have found that S implants had no affect on feed intake of steers (Dinius and Baile, 1977; Lomas, 1983). Galbraith and Watson (1978) reported that steers implanted with F,

TABLE 4. EFFECTS OF IMPLANT TREATMENTS ON AVERAGE DAILY GAINS<sup>a</sup> OF HOLSTEIN STEERS AT SPECIFIED WEIGHT AND IMPLANT PERIODS

Period	C <sup>b</sup>	SE	F	SE	R	SE	S	SE	F+S	SE	F+R	SE
56 d	1.39 <sup>d</sup>	± .04	1.58 <sup>c</sup>	± .04	1.53 <sup>c</sup>	± .05	1.53 <sup>c</sup>	± .05	1.66 <sup>c</sup>	± .04	1.61 <sup>c</sup>	± .04
112 d	1.48 <sup>e</sup>	± .17	1.60 <sup>d</sup>	± .17	1.60 <sup>d</sup>	± .17	1.65 <sup>d</sup>	± .18	1.76 <sup>c</sup>	± .17	1.68 <sup>cd</sup>	± .17
168 d	1.37 <sup>e</sup>	± .13	1.45 <sup>de</sup>	± .13	1.49 <sup>d</sup>	± .13	1.50 <sup>d</sup>	± .14	1.60 <sup>c</sup>	± .13	1.54 <sup>cd</sup>	± .13
205 d	1.32 <sup>e</sup>	± .13	1.42 <sup>d</sup>	± .13	1.45 <sup>d</sup>	± .14	1.45 <sup>d</sup>	± .14	1.55 <sup>c</sup>	± .13	1.49 <sup>cd</sup>	± .13
249 d	1.22 <sup>e</sup>	± .11	1.29 <sup>de</sup>	± .11	1.34 <sup>cd</sup>	± .12	1.34 <sup>cd</sup>	± .13	1.40 <sup>c</sup>	± .11	1.33 <sup>d</sup>	± .11
1st implant	1.39 <sup>d</sup>	± .04	1.58 <sup>c</sup>	± .04	1.53 <sup>c</sup>	± .05	1.53 <sup>c</sup>	± .05	1.66 <sup>c</sup>	± .04	1.61 <sup>c</sup>	± .04
2nd implant	1.57 <sup>e</sup>	± .23	1.64 <sup>de</sup>	± .23	1.68 <sup>de</sup>	± .24	1.77 <sup>cd</sup>	± .25	1.86 <sup>c</sup>	± .23	1.75 <sup>cd</sup>	± .23
3rd implant	1.16	± .31	1.14	± .31	1.25	± .32	1.19	± .34	1.30	± .31	1.25	± .31
4th implant	.90	± .20	.95	± .20	1.03	± .22	1.02	± .23	.99	± .20	.90	± .20

<sup>a</sup>Average daily gain is expressed in kg/d.

<sup>b</sup>C = Controls; F = Finaplix<sup>®</sup>; R = Ralgro<sup>®</sup>; S = Synovex<sup>®</sup>.

<sup>cde</sup>Mean values in the same row with different superscript letters differ (P < .05).



TABLE 5. EFFECTS OF IMPLANT TREATMENTS ON FEED INTAKE<sup>a</sup> (DRY MATTER AND AS FED BASIS) OF HOLETEIN STEERS

	C <sup>b</sup>	F	R	S	F+S	F+R	SE
<u>Dry Matter Basis</u>							
56 d	7.49	8.09	7.60	7.20	7.82	7.93	±.32
112 d	8.24	8.59	8.49	8.31	8.98	9.04	±.27
168 d	8.43	8.61	8.79	8.70	9.26	9.31	±.25
249 d	8.38	8.35	8.72	8.90	9.13	9.15	±.23
1st implant	7.49	8.09	7.60	7.20	7.82	7.93	±.32
2nd implant	9.00 <sup>e</sup>	9.09 <sup>e</sup>	9.37 <sup>e</sup>	9.42 <sup>de</sup>	10.15 <sup>cd</sup>	10.16 <sup>c</sup>	±.25
3rd implant	8.79 <sup>de</sup>	8.63 <sup>e</sup>	9.41 <sup>cd</sup>	9.42 <sup>cd</sup>	9.83 <sup>c</sup>	9.86 <sup>c</sup>	±.25
4th implant	8.27 <sup>de</sup>	7.83 <sup>e</sup>	8.57 <sup>cde</sup>	9.35 <sup>c</sup>	8.87 <sup>cd</sup>	8.80 <sup>cd</sup>	±.28
<u>As-fed basis</u>							
56 d	11.41	12.32	11.57	11.00	11.89	12.03	±.48
112 d	11.76	12.29	12.08	11.81	12.76	12.86	±.39
168 d	11.60	11.88	12.07	11.90	12.71	12.78	±.35
249 d	11.27	11.28	11.72	11.93	12.27	12.29	±.32
1st implant	11.41	12.32	11.57	11.00	11.89	12.03	±.48
2nd implant	12.12 <sup>e</sup>	12.26 <sup>de</sup>	12.60 <sup>de</sup>	12.66 <sup>de</sup>	13.64 <sup>cd</sup>	13.68 <sup>c</sup>	±.34
3rd implant	11.27 <sup>de</sup>	11.07 <sup>e</sup>	12.06 <sup>cd</sup>	12.08 <sup>cd</sup>	12.60 <sup>c</sup>	12.63 <sup>c</sup>	±.32
4th implant	10.61 <sup>de</sup>	10.04 <sup>e</sup>	10.99 <sup>cde</sup>	11.99 <sup>c</sup>	11.37 <sup>cd</sup>	11.28 <sup>cd</sup>	±.36

<sup>a</sup>Reported in kg/d.<sup>b</sup>C = Control; F = Finaplix®; R = Ralgro®; S = Synovex-S®.<sup>cde</sup>Mean values in the same row with different superscript letters differ (P < .05).

hexoestrol or F+hexoestrol tended to have larger dry-matter intakes than untreated steers, which is supported by our results. However, Trenkle (1987) showed that steers implanted twice with F and estradiol consumed less feed than cattle implanted once with F.

Feed efficiency data, based on either a dry matter or as-fed basis, are reported in Table 6. There were no significant ( $P>.05$ ) differences in either dry matter or as-fed feed-to-gain ratios among treatment groups for any weight period. Furthermore, implant treatment had no effect ( $P>.05$ ) on feed efficiency during the first, second or third implant periods. However, during the last implant period, F steers were more ( $P<.05$ ) efficient converters of feed to gain than F+R or C steers. Also, R steers were more ( $P<.05$ ) efficient than F+R steers. Control, S, F+S and F+R treatment groups had similar ( $P>.05$ ) feed-to-gain ratios.

Our results agree with those of Galbraith (1980), who indicated that F treated heifers converted feed to gain more efficiently (23%) than untreated heifers. Crouse et al. (1987) and Henricks et al. (1982) reported that heifers implanted with F tended to be more efficient converters of feed to gain than C. Moreover, Trenkle (1987) showed that implanting steers twice with F resulted in a 7.4% improvement in feed efficiency when compared to C steers. However, Heitzman and Chan (1974) reported that C heifers were more efficient converters of hay to gain than F-implanted heifers.

Combinations containing F and estrogenic implants have been shown to improve feed efficiency of steers when compared to C steers (Galbraith and Coelho, 1978; Galbraith and Dempster, 1979; Galbraith and Geraghty, 1982; Galbraith, 1982; Heitzman et al., 1981). However, in our study, feed efficiency of F+R steers was poorer than for R and F steers; F+S steers were intermediate in feed efficiency.

Evaluations of live animal masculinity and hindquarter muscling are presented in Table 7. Steers implanted with F+S and F+R were evaluated to be more ( $P<.05$ ) masculine in appearance than S and C steers. F and R steers were intermediate in masculinity scores.

These results agree with those of Brethour (1986) who found that F+S treatment

TABLE 6. EFFECTS OF IMPLANT TREATMENTS ON FEED-TO GAIN RATIOS<sup>a</sup> (DRY MATTER AND AS FED BASIS) OF HOLETEIN STEERS

	C <sup>b</sup>	F	R	S	F+S	F+R	SE
<u>Dry Matter Basis</u>							
56 d	5.39	5.14	4.96	4.72	4.71	4.94	± .19
112 d	5.57	5.35	5.28	5.03	5.11	5.38	± .14
168 d	6.14	5.94	5.91	5.80	5.78	6.05	± .17
249 d	6.88	6.49	6.52	6.63	6.50	6.87	± .15
1st implant	5.39	5.14	4.96	4.72	4.71	4.94	± .19
2nd implant	5.72	5.57	5.58	5.31	5.47	5.80	± .16
3rd implant	7.62	7.66	7.55	7.92	7.69	7.85	± .44
4th implant	9.27 <sup>cd</sup>	8.22 <sup>e</sup>	8.35 <sup>de</sup>	9.18 <sup>cde</sup>	8.94 <sup>cde</sup>	9.86 <sup>e</sup>	± .34
<u>As-fed basis</u>							
56 d	8.22	7.82	7.55	7.18	7.17	7.49	± .27
12 d	7.95	7.66	7.53	7.15	7.26	7.65	± .20
168 d	8.45	8.20	8.12	7.94	7.93	8.31	± .23
249 d	9.26	8.76	8.76	8.89	8.74	9.23	± .21
1st implant	8.22	7.82	7.55	7.18	7.17	7.49	± .27
2nd implant	7.71	7.51	7.50	7.14	7.35	7.81	± .23
3rd implant	9.78	9.80	9.69	10.15	9.89	10.06	± .50
4th implant	11.87 <sup>cd</sup>	10.53 <sup>e</sup>	10.70 <sup>de</sup>	11.77 <sup>cde</sup>	11.47 <sup>cde</sup>	12.63 <sup>e</sup>	± .43

<sup>a</sup>Ratio of feed consumed to 1 unit of gain.

<sup>b</sup>C = Control; F = Finaplix; R = Raigrow; S = Synovex-S®.

<sup>cde</sup>Mean values in the same row with different superscript letters differ (P < .05).

produced obvious masculine traits in steers, including curly faces, broad heads, thick necks and prominent crests. Furthermore, Wood et al. (1986) reported that Revalor implantation of steers increased weights of muscles in the neck, resulting in a more bull-like muscle distribution. Galbraith and Watson (1978) reported that implantation of F, alone, tended to give a bull-like appearance to steers when compared to untreated steers.

Implant treatment had no effects ( $P>.05$ ) on live animal hindquarter muscling as evaluated by the three-person panel. We speculated that F, F+S and F+R treatments would improve muscling scores of Holstein steers, which was a primary interest in planning this experiment.

Carcass Merit. Carcass cutability data and the factors affecting cutability are reported in Table 7. There were no significant ( $P>.05$ ) differences among treatment groups for dressing percent. Our results contradict the findings of Stollard and Jones (1980), Galbraith et al. (1981) and Griffiths (1982) who found that dressing percent was increased in steers implanted with F combinations. On the other hand, Heitzman et al. (1981), Keane et al. (1986) and Keane (1987) reported that the dressing percent of steers implanted with F+R, F+S or F+Compudose was similar to the dressing percent of untreated steers, which is in agreement with our results.

Actual fat thicknesses and adjusted fat thicknesses were unaffected ( $P>.05$ ) by implant treatment. Our results are contradictory to those of Wood et al. (1986), who reported that Revalor-treated steers were fatter than C steers, and had a higher subcutaneous to intermuscular fat ratio. However, Galbraith and Watson (1978) and Keane (1987) reported that fat score (a subjective assessment of subcutaneous fat cover) was unaffected by treatment with F+S, F+R and F+estradiol-17 $\beta$ , which is in agreement with our findings. It should be pointed out that all of our steers had desirably trim fat thicknesses.

There were no differences ( $P>.05$ ) in percent kidney, heart and pelvic (KHP) fat among implant treatments. Our results support those of Galbraith et al. (1983) and Keane and Sherington (1985b) who found mean weights of kidney and pelvic fat were similar for C and

TABLE 7. EFFECTS OF IMPLANT TREATMENTS ON LIVE EVALUATIONS OF MASCULINITY AND MUSCLING, AND CARCASS YIELD GRADE DATA OF HOLSTEIN STEERS

Item	C <sup>a</sup>	SE	F	SE	R	SE	S	SE	F+S	SE	F+R	SE
Live masculinity score <sup>b</sup>	1.5 <sup>c</sup>	± .22	1.9 <sup>de</sup>	± .22	1.7 <sup>de</sup>	± .23	1.5 <sup>e</sup>	± .24	2.1 <sup>d</sup>	± .22	2.0 <sup>d</sup>	± .22
Live hindquarter muscling score <sup>c</sup>	2.2	± .12	1.7	± .12	2.3	± .13	2.6	± .14	2.5	± .12	2.4	± .12
Dressing percent	59.6	± .33	59.1	± .33	60.0	± .34	60.2	± .36	60.0	± .33	59.7	± .33
Hot carcass wt, kg	289.5 <sup>f</sup>	± 8.75	296.7 <sup>ef</sup>	± 8.75	308.8 <sup>d</sup>	± 9.23	313.4 <sup>d</sup>	± 9.68	317.4 <sup>d</sup>	± 8.75	306.3 <sup>de</sup>	± 8.75
Actual fat thickness, mm	6.4	± .13	4.9	± .13	6.0	± .13	5.1	± .14	5.1	± .13	5.5	± .13
Adjusted fat thickness, mm	6.8	± .13	5.6	± .13	7.2	± .14	7.0	± .15	5.8	± .13	6.7	± .13
Ribeye area, cm <sup>2</sup>	66.44 <sup>f</sup>	± 1.78	71.60 <sup>ef</sup>	± 1.78	70.31 <sup>ef</sup>	± 1.89	72.24 <sup>de</sup>	± 1.98	77.40 <sup>d</sup>	± 1.78	73.53 <sup>de</sup>	± 1.78
Kidney, heart and pelvic fat, %	2.96	± .19	3.38	± .19	3.01	± .20	2.94	± .21	2.54	± .19	2.75	± .19
USDA yield grade	3.0 <sup>h</sup>	± .11	2.88 <sup>g</sup>	± .11	3.0 <sup>h</sup>	± .12	2.9 <sup>h</sup>	± .13	2.58 <sup>g</sup>	± .11	2.78 <sup>h</sup>	± .11
Hindquarter muscling score <sup>c</sup>	4.6	± .26	4.3	± .26	5.4	± .27	4.9	± .29	5.0	± .26	5.0	± .26

<sup>a</sup>C = Control; F = Finaplix; R = Ralgor; S = Synovex-S<sub>o</sub>.

<sup>b</sup>1 = steer; 2 = slightly masculine; . . . ; 5 = very masculine.

<sup>c</sup>1 = extremely thin; 2 = very thin; . . . ; 4 = moderately thin; 5 = slightly thin; . . . ; 10 = extremely thin.

<sup>def</sup>Mean values in the same row with different superscript letters differ (P < .05).

<sup>gh</sup>Mean values in the same row with different superscript letters differ (P = .07).

Revalor and F+R treated steers . However, our results are contradictory to those of Heitzman et al. (1981), who reported less omental and KHP fat in Revalor-treated steers, and Silcox et al. (1986), who reported that bulls implanted with F+R had significantly more KHP fat than C bulls or those implanted with R or F.

Hindquarter muscling scores were not affected ( $P > .05$ ) by implant treatment. Our results agree with those of Galbraith and Watson (1978) who reported that subjective scores of carcass conformation of steers treated with hexoestrol, F or a combination of the two, were similar to those of untreated steers. However, Keane and Sherington (1985b), Keane et al. (1986) and Keane (1987) reported that conformation was improved by implantation of steers with combination implants containing F with either estradiol, R or S, when compared to controls. It should be noted that the difference between live and carcass evaluated hindquarter muscling scores can be explained by the fact that the scoring system was devised for carcasses and not for live animals. We speculated that F, alone or in combination, would improve muscling scores in these young Holstein steers.

Hot carcass weights of R, S and F+S steers were heavier ( $P < .05$ ) than those of either F or C steers. Also, hot carcass weights for F+R steers were heavier ( $P < .05$ ) than those for C steers, whereas weights for F+R steers were not different ( $P > .05$ ) than those for F steers. Griffiths (1982) indicated that carcass weights of F+R steers were heavier than non-implanted steers. Furthermore, Keane and Sherington (1985b) found that carcasses from steers implanted with F+S were heavier than those from steers implanted with F+R. Keane (1987) reported that carcass weights were higher in steers implanted with F+S than for Compudose and C steers; however, there were no differences among F+S, F+R and F+Compudose treatment groups.

Carcasses from F+S treated steers had larger ( $P < .05$ ) longissimus muscle (LM) area than R, F and C steers; LM areas of F+R, F+S and S carcasses were similar ( $P > .05$ ). Longissimus muscle area has been shown to be increased by implantation of steers with R (Cohen and Cooper, 1983) and S (Rumsey, 1982; Lomas, 1983). Trenkle (1987) reported that F,

TABLE 8. EFFECTS OF IMPLANT TREATMENTS ON HIDE-PULL SCORES AND QUALITY TRAITS OF HOLSTEIN STEERS

Item	C <sup>a</sup>	SE	F	SE	R	SE	S	SE	F+S	SE	F+R	SE
Hide-pull score <sup>b</sup>	1.3 <sup>kl</sup>	.18	1.9 <sup>jk</sup>	.18	1.3 <sup>kl</sup>	.18	1.6 <sup>k</sup>	.19	3.1 <sup>l</sup>	.18	2.3 <sup>l</sup>	.18
Skeletal maturity <sup>c</sup>	48.0 <sup>kl</sup>	2.90	44.0 <sup>l</sup>	2.90	56.0 <sup>jk</sup>	3.06	59.0 <sup>jl</sup>	3.21	67.0 <sup>l</sup>	2.90	59.0 <sup>jl</sup>	2.90
Lean maturity <sup>c</sup>	52.0	2.24	58.0	2.24	51.0	2.36	55.0	2.48	48.0	2.24	52.0	2.24
Overall maturity <sup>c</sup>	49.0 <sup>l</sup>	2.42	48.0 <sup>l</sup>	2.42	53.0 <sup>jl</sup>	2.55	57.0 <sup>l</sup>	2.68	59.0 <sup>l</sup>	2.42	58.0 <sup>l</sup>	2.42
Marbling score <sup>d</sup>	280.0	27.24	291.0	27.24	265.0	28.72	235.0	30.12	233.0	27.24	253.0	27.24
Quality grade <sup>e</sup>	226.0	11.82	227.0	11.82	219.0	12.46	207.0	13.07	200.0	11.82	213.0	11.82
Lean color score <sup>f</sup>	4.2 <sup>jk</sup>	.12	4.6 <sup>l</sup>	.12	4.2 <sup>jk</sup>	.13	4.3 <sup>jl</sup>	.14	4.0 <sup>jk</sup>	.12	3.9 <sup>k</sup>	.12
Firmness score <sup>g</sup>	1.3	.18	1.4	.18	1.7	.19	1.8	.20	1.8	.18	1.4	.18
Heat ring score <sup>h</sup>	1.3	.16	1.3	.16	1.1	.16	1.2	.17	1.2	.16	1.2	.16
No. $\pm$ Choice <sup>-</sup>	12 of 12		9 of 12		9 of 11		9 of 10		6 of 12		10 of 12	
Choice, %	100		75		82		90		50		83	

<sup>a</sup>C = Control; F = Finaplix<sup>®</sup>; R = Ralgron<sup>®</sup>; S = Synovex-S<sup>®</sup>.

<sup>b</sup>1 = easy; . . . ; 5 = extremely difficult.

<sup>c</sup>0 to 99 = A maturity and 100 to 199 = B maturity.

<sup>d</sup>100 to 199 = Slight; 200 to 299 = Small; 300 to 399 = Modest.

<sup>e</sup>0 to 99 = USDA Standard; 100 to 199 = USDA Select; 200 to 299 = USDA Choice.

<sup>f</sup>1 = bleached red; . . . ; 4 = cherry red; 5 = slightly dark red; . . . ; 8 = very dark red.

<sup>g</sup>1 = very firm; 2 = firm; . . . ; 7 = extremely soft.

<sup>h</sup>1 = none; 2 = slight; . . . ; 5 = extremely severe.

<sup>ijk</sup>Mean values in the same row with different superscript letters differ (P < .05).

estradiol and the combination of the two increased LM areas over C steers. Furthermore, Galbraith et al. (1981) reported that steers implanted with Revalor had significantly greater LM areas than C steers. However, Fisher et al (1986b) reported that there was a tendency for bulls treated with Revalor to have smaller LM dimensions than C bulls. Therefore, it appears that S, F+S and F+R will increase the LM areas in Holstein steers.

Carcasses from F+S steers tended ( $P=.07$ ) to have lower numerical USDA yield grades than carcasses from S, R, or C steers. It should be noted that all treatments resulted in carcasses with desirable yield grades of 3.0 or less.

Most research involving androgenic-estrogenic combination implants has been performed in Europe; therefore, literature reporting the affects of combination implants on yield grades is limited. Our results support the findings of Griffiths (1981; 1982), who found that carcasses of F+R steers contained a significantly higher proportion of lean and less trimmable fat than C steers. However, Hartman (1989) indicated that USDA yield grades were similar for C, S and F+S treatment groups.

Data pertaining to carcass quality and hide pull scores are presented in Table 8. Hides of F+S steers were scored more ( $P<.05$ ) difficult to remove than the hides of all other treatments. The F+R steers had higher ( $P<.05$ ) hide pull scores than S, R and C steers, whereas F and F+R treatments received similar ( $P>.05$ ) scores.

Hartman (1989) reported that there was a tendency (non significant) for increased difficulty in hide pull and increased hide weight in heifers implanted with F. Fisher et al. (1986b) indicated that steers implanted with Revalor had heavier hide weights, relative to the hide weights of C bulls. These results and ours suggest that androgenic-estrogenic combination implants produce more masculine animals with heavier hides which are more difficult to remove than those of non-implanted controls.

Skeletal maturity was increased ( $P<.05$ ) in carcasses of steers implanted with F+S, F+R and S, even though steers were slaughtered at similar chronological ages. Carcasses of steers



treated with F had younger ( $P < .05$ ) skeletal maturity than all other implant treatments. There were no differences ( $P > .05$ ) in lean maturity among the six treatment groups. The overall maturity of S, F+S and F+R groups was significantly ( $P < .05$ ) greater than that for carcasses of F and C steers.

Vanderwert et al. (1985) found that R implantation increased overall maturity over C. Furthermore, they indicated that R had greater negative effects on maturity among steers than it did among bulls. Prichard et al. (1984), also showed that R implants increased both lean and overall maturity significantly when compared to C steers. Greathouse et al. (1983) reported higher scores for both skeletal and overall maturity in carcasses from R-treated bulls, even though R bulls were slaughtered at younger chronological ages than C bulls. Unruh et al. (1986a), Ford and Gregory (1983), Johnson et al. (1984) and Johnson et al. (1986) reported that overall maturity was unaffected in bulls treated with anabolic agents. Furthermore, Crouse et al. (1987) indicated that maturity of heifers implanted with F was similar to C.

Mean marbling scores and quality grades were not ( $P > .05$ ) affected by implant treatments. However, only 50% of the F+S carcasses graded low Choice or better, compared to 100, 75, 82, 90 and 83% for C, F, R, S and F+R carcasses, respectively. Hartman (1989) reported that F implanted cattle tended to have reduced marbling scores. Also, he showed that, in one trial, cattle implanted with either S or F+S had lower marbling scores and reduced percentages grading low Choice or better than cattle implanted with R or F+R. Trenkle (1987) found that, in carcasses from steers implanted with F alone, marbling and quality grades tended to be lower than C and those implanted with estradiol or F plus estradiol. Furthermore, Brethour (1986) reported that marbling score and quality grade were lowered when steers were implanted with F+S and F+R.

There were no ( $P > .05$ ) differences in lean firmness scores and incidence of heat ring development among implant treatments. Crouse et al. (1987) reported that F had no effect on lean texture or firmness of heifers. Johnson and Dikeman (1988) found that LM texture and

firmness were judged very desirable, and the incidence of heat ring was negligible when bulls implanted with F+R were compared to C bulls. Furthermore, Greathouse et al. (1983), Ford and Gregory (1983) and Unruh et al. (1986b) have all reported that lean texture and firmness were unaffected by R implantation of bulls.

Although all implant treatments resulted in an acceptable cherry-red lean color, upon statistical analyses, carcasses of steers implanted with F were darker ( $P < .05$ ) than carcasses of R, F+S, F+R and C steers.

Results of our study contradict the findings of Crouse et al. (1987), who reported that lean color did not vary between F and C heifers. Johnson and Dikeman (1988) indicated that LM color was very desirable for both F+R and C bulls. Brethour (1986) noted that steers implanted with F+S produced some dark-cutting carcasses; however, he attributed this observation to an extended time between time of arrival at the packing plant and the time the cattle were slaughtered. In subsequent trials when cattle were slaughtered soon after arrival at the packing plant, no additional dark-cutters were observed.

Longissimus Sensory Characteristics. Implanting had no effects ( $P > .05$ ) on sensory panel flavor intensity, juiciness, amount of detectable connective tissue or incidence of off flavors (Table 9). Sensory panel scores for myofibrillar and overall tenderness tended ( $P = .07$ ) to be lower for steaks from steers implanted with S and F+R than steaks from R and C steers. However, WBS values were similar ( $P > .05$ ) among treatment groups.

Stout et al. (1981) reported that C steers were evaluated as being more tender than S-implanted steers. However, Johnson et al. (1984) found no difference in panel-evaluated tenderness when S-implanted bulls were compared to C bulls.

When veal calves were subjected to implantation with Revalor and Forplix, van Weerden (1984) reported neither treatment affected cooked LM shear values. In addition, sensory-panel tenderness was scored significantly higher for C calves than Revalor-treated calves. However, in a study comparing F+R implanted bulls and steers and C bulls, Johnson and Dikeman (1988)

TABLE 9. EFFECTS OF IMPLANT TREATMENTS ON WARNER-BRATZLER SHEAR (WBS) FORCE AND SENSORY PANEL EVALUATION SCORES

Item	C <sup>a</sup>	SE	F	SE	R	SE	S	SE	F+S	SE	F+R	SE
WBS, kg	4.01 ± .18		4.06 ± .18		4.01 ± .18		3.93 ± .19		4.30 ± .18		4.35 ± .20	
Flavor intensity <sup>b</sup>	6.1 ± .08		6.1 ± .08		6.2 ± .08		6.0 ± .09		5.9 ± .08		5.9 ± .09	
Juiciness <sup>c</sup>	5.9 ± .19		6.1 ± .19		6.1 ± .20		5.6 ± .21		5.7 ± .19		5.7 ± .22	
Myofibrillar tenderness <sup>d</sup>	6.4 <sup>g</sup> ± .12		6.1 <sup>gh</sup> ± .12		6.4 <sup>g</sup> ± .13		5.9 <sup>h</sup> ± .14		6.1 <sup>gh</sup> ± .12		5.9 <sup>h</sup> ± .14	
Amount of connective tissue <sup>e</sup>	7.3 ± .10		7.1 ± .10		7.3 ± .11		7.1 ± .12		7.2 ± .10		7.1 ± .12	
Overall tenderness <sup>f</sup>	6.5 <sup>g</sup> ± .11		6.3 <sup>gh</sup> ± .11		6.6 <sup>g</sup> ± .11		6.1 <sup>h</sup> ± .12		6.3 <sup>gh</sup> ± .11		6.1 <sup>h</sup> ± .12	
Off flavor intensity <sup>7</sup>	7.9 ± .06		7.9 ± .06		7.7 ± .06		7.8 ± .06		7.8 ± .06		7.8 ± .06	

<sup>a</sup>C = Control; F = Finaplix<sup>®</sup>; R = Ralgro<sup>®</sup>; and S = Synovex-S<sup>®</sup>.

<sup>b</sup>1 = extremely bland; . . . ; 5 = slightly intense; 6 = moderately intense; . . . ; 8 = extremely intense.

<sup>c</sup>1 = extremely dry; . . . ; 5 = slightly juicy; 6 = moderately juicy; . . . ; 8 = extremely juicy.

<sup>d</sup>1 = extremely tough; . . . ; 5 = slightly tender; 6 = moderately tender; . . . ; 8 = extremely tender.

<sup>e</sup>1 = abundant; . . . ; 7 = practically none; 8 = none.

<sup>f</sup>1 = extremely intense; . . . ; 7 = practically none; 8 = none.

<sup>g</sup>Mean values in the same row with different superscript letters differ ( $P \leq .07$ ).

reported that implanting bulls had no significant effects on either myofibrillar, overall tenderness, or WBS force. They also reported that there was no significant effect of F+R implantation on flavor intensity or juiciness in steers and bulls, which is in agreement with our results.

Furthermore, sensory-panel evaluations of juiciness, flavor and overall desirability have been reported to be unaffected by implantation of steers with R (Borger et al., 1973; Smithson et al., 1973). However, Stout et al. (1981) indicated that C steers yielded steaks that tended to be juicier and more desirable than those from S treated steers.

## CONCLUSIONS

Our results indicate that implanting Holstein steers with the combination of F+S resulted in an additive growth effect compared to steers implanted singularly with F or S. On the other hand, the more masculine F+S steers had higher DMI than C and F steers; but, no advantage in feed efficiency. Also, F+S-implanted steers had heavier carcasses than F and C, and larger LM than F, R and C steers. Even though carcasses from F+S steers had more desirable yield grades than R, S and C, only 50% of their carcasses graded low Choice or higher.

Steers implanted with Finaplix® alone had higher ADG than C at only two specified weight periods and more efficient utilization of feed than steers implanted with F+R and C steers. However, there were no practical differences between C and F steers for any carcass traits.

The S, R and F+R treatments resulted in similar ADG and DMI; however, F+R steers were less efficient than R steers. With the exception that carcasses were lighter for F+R steers than S, carcass traits were similar among R, S and F+R treatments. Generally, carcass traits were superior for these three treatments than for C. However, steaks from S and F+R steers were less tender than steaks from R and C steers.

Implantation of young, light-weight Holstein steers resulted in larger LM compared to C, which has been perceived as disadvantages of Holstein steers. 83% of all carcasses graded USDA Choice and averaged only 6.6 mm of fat thickness.

## IMPLICATIONS

The Finaplix plus Synovex-S combination may result in the highest ADG in young, light-weight Holstein steers. This combination may also result in carcasses with an advantage in muscling and trimness. On the other hand, this treatment combination may result in a lower proportion of USDA Choice carcasses; however, there was no detrimental effect on longissimus palatability.

Holstein steers can satisfy consumers' demands for lean, high quality beef. Feeding young, light-weight Holstein steers can result in a high percentage of Choice carcasses of desirable weights and very desirable USDA yield grades.

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## APPENDIX I

## LIVE MASCULINITY SCORE DESCRIPTIONS

- 1 = **Steer** -- No prominent facial features over the eye brow and jaw; narrow and long head in relations to body size; refined head crest and neck; smooth, little muscular development of crest, shoulder, rib and hindquarter; and fine hair coat texture, especially over the head.
- 2 = **Slightly Masculine** -- Slight prominence of eye brow and facial features; somewhat narrow and long head in relation to body size; somewhat refined head, crest and neck; somewhat smooth and moderate muscular development; and moderate fine hair coat.
- 3 = **Moderately Masculine** -- Somewhat prominent brow and facial features; moderate relationship of length and width of head to body size; slight fullness of head, crest and neck; moderate muscular development of crest, shoulder, rib and hindquarter; and slightly coarse hair coat.
- 4 = **Masculine** -- Prominent brow and facial features; moderately wide head in relation to length; full head, crest and neck; muscular through crest, shoulder, rib and hindquarter; and coarse hair texture.
- 5 = **Very Masculine** -- Very prominent eye brow and facial features; relatively wide head in relation to length; very full head, crest and neck; high degree of muscular development through the crest, shoulder, rib and hindquarter; and very coarse hair coat.

## APPENDIX II

## HINDQUARTER MUSCLING SCORE DESCRIPTION

- 1 = **Extremely Thin** -- An extremely thin, extremely concave round with absolutely no expression or flare; extremely prominent hooks and pins; and deficient of sirloin (sunken appearance).
- 2 = **Very Thin** -- A very thin, very concave round with no expression of muscling or flare; very prominent hooks and pins; and a very thin and sunken sirloin.
- 3 = **Thin** -- A thin, concave round with no expression of muscling or flare; moderately prominent hooks and pins; and a thin and sunken sirloin.
- 4 = **Moderately Thin** -- A thin, slightly concave round with no expression of muscling; slight prominence of hooks and pins; and a slightly sunken sirloin.
- 5 = **Slightly Thin** -- A slightly thin round showing little expression; slightly concave appearance; and no expression of sirloin.
- 6 = **Slightly Thick** -- A slightly expressive round with a slight amount of inside and outside flare; slightly thick and slightly plump round; and a slight amount of prominence of the sirloin.
- 7 = **Moderately Thick** -- A moderately expressive round; a moderately thick and moderately plump round with a moderate amount of inside and outside flare; and a moderately prominent sirloin.
- 8 = **Thick** -- An expressive round; a thick and plump round with a slightly extreme amount of inside and outside flare; and a prominent sirloin.
- 9 = **Very Thick** -- A very expressive round; a very thick and very plump round with a moderately extreme amount of inside and outside flare; and a very prominent sirloin.
- 10 = **Extremely Thick** -- Extremely expressive round with an extreme amount of inside and outside flare; an extremely thick and extremely plump round; and an extremely prominent sirloin.

## APPENDIX III

## CARCASS EVALUATION SCORE DESCRIPTIONS

## COLOR SCORE DESCRIPTION

- 1 = Bleached Red
- 2 = Very Light Cherry Red
- 3 = Moderately Light Cherry Red
- 4 = Cherry Red
- 5 = Slightly Dark Red
- 6 = Moderately Dark Red
- 7 = Dark Red
- 8 = Very Dark Red

## LEAN FIRMNESS SCORE DESCRIPTION

- 1 = Very Firm
- 2 = Firm
- 3 = Moderately Firm
- 4 = Slightly Soft
- 5 = Soft
- 6 = Very Soft
- 7 = Extremely Soft

## HEAT RING INCIDENCE SCORE DESCRIPTION

- 1 = None
- 2 = Slight
- 3 = Moderate
- 4 = Severe
- 5 = Extremely Severe

## APPENDIX IV

## SENSORY PANEL EVALUATION SCORE DESCRIPTIONS

Flavor Intensity

- 8 = Extremely Intense
- 7 = Very Intense
- 6 = Moderately Intense
- 5 = Slightly Intense
- 4 = Slightly Bland
- 3 = Moderately Bland
- 2 = Very Bland
- 1 = Extremely Bland

Juiciness

- 8 = Extremely Juicy
- 7 = Very Juicy
- 6 = Moderately Juicy
- 5 = Slightly Juicy
- 4 = Slightly Dry
- 3 = Moderately Dry
- 2 = Very Dry
- 1 = Extremely Dry

Myofibrillar Tenderness

- 8 = Extremely Tender
- 7 = Very Tender
- 6 = Moderately Tender
- 5 = Slightly Tender
- 4 = Slightly Tough
- 3 = Moderately Tough
- 2 = Very Tough
- 1 = Extremely Tough

Connective Tissue  
Amount

- 8 = None
- 7 = Practically None
- 6 = Traces
- 5 = Slight
- 4 = Moderate
- 3 = Sl. Abundant
- 2 = Mod. Abundant
- 1 = Abundant

Overall Tenderness

- 8 = Extremely Tender
- 7 = Very Tender
- 6 = Moderately Tender
- 5 = Slightly Tender
- 4 = Slightly Tough
- 3 = Moderately Tough
- 2 = Very Tough
- 1 = Extremely Tough

Off Flavor Intensity

- 8 = None
- 7 = Practically None
- 6 = Traces
- 5 = Slight
- 4 = Slightly Intense
- 3 = Mod. Intense
- 2 = Very Intense
- 1 = Extremely Intense

## APPENDIX V

INSTRON 4201 WARNER-BRATZLER SHEAR FORCE DETERMINATION  
PROCEDURE

- |    |                                                                                                                                                                                            |                |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| 1. | Load Cell                                                                                                                                                                                  | 50 kg          |
| 2. | Load Rang                                                                                                                                                                                  | 10 kg          |
| 3. | Speed                                                                                                                                                                                      | 200 mm/min.    |
| 4. | Proportion<br>(crosshead:recorder)                                                                                                                                                         | 2:1            |
| 5. | Maximum and Status                                                                                                                                                                         | 0 and stop     |
| 6. | Gauge length                                                                                                                                                                               | 0              |
| 7. | Minimum and Status                                                                                                                                                                         | -35 and return |
| 8. | Sample<br>Specifications:1.27 cm cores from steaks cooked to 70 C internal doneness and cooled 2 h before coring with a mechanical coring device perpendicular to the steak's cut surface. |                |



EFFECTS OF FINAPLIX<sup>®</sup>, SYNOVEX-S<sup>®</sup> AND RALGRO<sup>®</sup> IMPLANTS,  
SINGULARLY OR IN COMBINATIONS, ON PERFORMANCE, CARCASS  
TRAITS AND LONGISSIMUS PALATABILITY OF  
HOLSTEIN STEERS

by

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B.S., Oklahoma State University, 1987

AN ABSTRACT OF A MASTER'S THESIS

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## ABSTRACT

Seventy-two holstein steers averaging 182 kg were used to evaluate the following implant treatments: (1) non-implanted control (C); (2) implanted with Ralgro® (R); (3) implanted with Synovex-S® (S); (4) implanted with Finaplix® (F); (5) implanted with Finaplix and Synovex-S (F+S) and (6) implanted with Finaplix and Ralgro (F+R). Each treatment group consisted of three replications of 4 animals/pen, which were reimplanted on d 56, 112 and 168. Steers were stepped up to a finishing diet and fed to consumption twice daily. Masculinity and muscling scores were assigned at 24 h pre-slaughter. Hide removal difficulty was scored by a plant supervisor. Quality and yield grade data were obtained at 24 h postmortem. Longissimus muscle (LM) steaks were removed and cooked for Warner-Bratzler shear (WBS) determinations and sensory panel (SP) evaluations. Over the entire feeding period (249 d), F+S steers had higher ( $P<.05$ ) ADG than F+R, F and C steers. All treatments had higher ( $P<.05$ ) ADG than C, with the exception of F. The only feed efficiency differences were during the fourth implant period, when F steers were more ( $P<.05$ ) efficient than F+R or C steers. The F+S and F+R steers had higher ( $P<.05$ ) masculinity and hide pull scores than S and C steers. Carcass weights of F+S steers were heavier ( $P<.05$ ) than those of F or C steers. The F+S steers had larger ( $P<.05$ ) LMA than R, F and C groups. Also, F+S steers tended ( $P=.07$ ) to have lower yield grades than S, R or C steers. Even though mean marbling scores and quality grades were similar ( $P>.05$ ) among treatment groups, only 50% of F+S carcasses graded low Choice or better compared to 100, 75, 82, 90 and 83% for C, F, R, S and F+R carcasses, respectively. The only meat palatability differences were that myofibrillar and overall tenderness scores were lower ( $P<.07$ ) for steaks from S and F+R than from R and C groups.

(Key words: Implants, Average Daily Gain, Carcass Traits, Feed Efficiency, Holsteins, Meat Palatability).