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# Effects of Anabolic Implants and Breed Group on Carcass Traits and Palatability Characteristics of Bullock Beef

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# EFFECTS OF ANABOLIC IMPLANTS AND BREED GROUP ON CARCASS TRAITS AND PALATABILITY CHARACTERISTICS OF BULLOCK BEEF

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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# PREFACE

The ultimate goal of the beef industry is efficient production of beef that satisfies the consumer and increases demand. In the past, American producers have been primarily interested in the production of high quality beef because consumers were concerned with meat palatability, particularly tenderness. However, due to current diet-health issues and economic conditions, American consumers have come to expect acceptable palatability and are now more concerned with the nutrient density and cost of their meat purchases.

Maximum production efficiency must be realized to keep beef competitive with other protein sources for consumer dollars. Production systems must be used that are capable of producing more lean beef per animal on less feed without sacrificing palatability. Since the ratio between feed costs for gains of fat and muscle is about 7 to 1 (Blaxter, 1964), the over-fattening of an animal in an effort to obtain more tender meat is no longer economically feasible.

Anabolic agents in the form of subcutaneous implants have been used since the early 1950's to increase the production efficiency of slaughter beef cattle. Implants have been developed for steers and heifers that have led to improvements of about 15% in growth rate and about 10% in feed conversion efficiency (Heitzman, 1978b). Success with these growth-promoting compounds has been shown particularly in intensive rearing situations.

One of the greatest immediate opportunities available to the beef industry for reducing production costs is the producing, feeding and marketing of intact males. Research discussed later indicates intact males grow more rapidly, utilize feed more efficiently and produce a higher yielding carcass (more retail product) with less fat and more muscle than castrates. Although intact males increase production efficiency, considerable resistance in traditional marketing channels has been encountered for beef from young, intact males. Seideman et al. (1982) indicated young bulls have a low packer acceptance because of difficult hide removal, heavy carcass weights and low USDA quality grades. The authors also suggested packer unacceptability has been associated with the belief that beef from bulls has lower consumer acceptance at the retail level because of differences in color, texture and fat distribution. In addition, cooked meat from intact males is often less tender than steer beef.

The effects of anabolic agents on intact males have been reported in only a limited number of studies. In one such study, Forrest (1968) concluded no benefits accrue from implanting young bulls with progesterone-estradiol in terms of growth rate, feed efficiency or lean content. However, Forrest recommended that young bulls reared for meat production be implanted, since these hormones will increase the deposition of fat to a more desirable level without decreasing rate of gain.

The objectives of this study were to determine the effects of implanted anabolic agents on the cutability and quality of carcasses from intact males of two breed groups and to study the sensory traits of beef derived from these intact males.

Mode of Action of Anabolic Agents

Numerous review articles (Baker and Arthaud, 1972; Preston, 1975; Buttery et al., 1978; Heitzman, 1978a,b; Scott, 1978) have stated the use of anabolic agents in farm animals results in more efficient production of meat by increasing live weight gain and improving overall feed efficiency. Scott (1978) indicated anabolic agents have the capability of modifying or supplementing the effects of the endogenous hormones that control and coordinate the metabolic processes of growth and fattening. None of these anabolic agents alter absorption or metabolism of nutrients consumed, but their primary action is via alterations of intermediary metabolism in the animal (Preston, 1975; Heitzman, 1978a; Scott, 1978).

Heitzman (1978a,b) divided anabolic agents into three classes, (1) androgens, (2) estrogens and (3) progestins, since anabolic agents used in animal production have functional properties similar to those of sex steroids. The common action of all anabolic agents is to increase the rate of nitrogen retention and protein deposition (Baker and Arthaud, 1972; Preston, 1975; Heitzman, 1978a,b; Scott, 1978). It is not known exactly how anabolic agents affect protein metabolism, but studies with laboratory animals indicate the methods by which the various classes of anabolic agents influence protein metabolism are very different.

Heitzman (1978a) stated androgens may have a direct action at the muscle cell level on protein synthesis and degradation and may work through the endogenous hormone thyroxine. Considerable evidence supports the view that estrogens and progestins exert their primary effect in the production of specific proteins in tissues like the uterus, the liver and the chick oviduct, but they do not appear to directly induce protein deposition in skeletal muscle (Heitzman, 1978a,b). Several postulated modes of action of estrogens were reviewed by Preston (1975). The most plausible hypothesis indicated by Preston was that estrogens act by altering the pattern of endogenous anabolic hormones, particularly growth hormone and insulin. Heitzman (1978a) reported the effects on growth of exogenous estrogen and growth hormone were similar and concluded that one of the main actions of estrogens, especially in males, was the increased production of growth hormone and insulin. Heitzman (1978a,b) and Scott (1978) have suggested androgens and estrogens are both necessary to realize the maximum growth potential in cattle, since they appear to stimulate growth by different mechanisms. Heitzman (1978a) concluded the best exogenous steroid treatment would be one that maintains or mimics maximum physiological levels of androgens and estrogens in circulating body fluids.

Effects of Anabolic Agents on Growth, Carcass and Palatability Traits

Diethylstilbestrol. From 1954 to 1973, synthetic estrogens were the major hormonal compounds used as additives in the production of meat by the livestock industry in the Unites States (Preston, 1975). In a review of the biological responses of cattle and lambs to estrogen additives, Preston reported diethylstilbestrol (DES or stilbestrol) implants were capable of increasing body weight gain and improving feed efficiency in females and castrated males. When used in an appropriate manner, Heitzman (1978b) and Thomas (1979) stated improvements of about

15% in growth rate and about 10% in feed conversion efficiency could be achieved in feedlot steers and heifers with DES implants.

Contrary to results obtained for DES-implanted steers and heifers, the use of DES implants in intact male cattle has produced inconsistent feedlot performance results. Baker and Arthaud (1972) reviewed 40 research papers on this topic and concluded there is a general lack of gain stimulation in bulls treated with estrogens at dose levels used in steers. Increased daily gains of bulls associated with high levels of DES implants have been reported by Klosterman et al. (1955), Bailey et al. (1966), Hunsley et al. (1967) and Martin and Stob (1978). Casas and Raun (1964) found high dose levels of DES did not affect weight gain during the first 56 d following implantation. However, in the subsequent 56 d, DES-implanted bulls gained faster than controls. Garrigus et al. (1969) reported DES implants improved daily gain of bulls during the first 84 d on feed but did not improve total performance over a 168-d feeding period. No effect of high levels of DES implants on daily gains of bulls was found by Koger et al. (1960), Laflamme and Burgess (1973) and Williams et al. (1975a,b).

Preston (1975) stated DES implants increased carcass cutability in steers by enhancing protein utilization and deposition. In contrast, a tendency for decreased yield of edible portion has been shown in studies using DES implants in feedlot bulls (Klosterman et al., 1955; Cahill et al., 1956; Martin et al., 1965; Hunsley et al., 1967; Hedrick et al., 1969). The tendency for decreased edible portion was due to negative effects of increased fat deposition and(or) decreased muscle development.

Several researchers (Kunkle et al., 1955: Cahill et al., 1956; Casas and Raun, 1964; Martin et al., 1965; Bailey et al., 1966; Hunsley et al., 1967; Garrigus et al., 1969; Ray et al., 1974; Williams et al., 1975b; Levy et al., 1976; Martin and Stob, 1978) reported a tendency for DES implants to increase subcutaneous and(or) internal fat deposition in slaughter bulls. Williams et al. (1975a) found DES-implanted beef bulls were significantly fatter than control bulls. This response was similar to that observed with intact cockerels (Lorenz, 1943, 1945; Andrews and Bohren, 1947). Significant decreases in longissimus muscle area of bulls due to DES implantation were noted by Cahill et al. (1956) and Laflamme and Burgess (1973), while other studies (Martin et al., 1965; Garrigus et al., 1969; Hedrick et al., 1969; Williams et al., 1975a) demonstrated only a tendency for longissimus muscle area reduction due to DES implants in bulls.

Changes in intramuscular fat deposition have been highly variable in response to diethylstilbestrol implants (Preston, 1975). Garrigus et al. (1969), Hedrick et al. (1969) and Martin and Stob (1978) observed no difference in marbling level between control and DES-implanted bulls. However, results presented by Martin et al. (1965) and Williams et al. (1975a,b) showed slight increases in marbling level due to DES implants. Ether-extract values have been found to increase due to DES implantation in Holstein bulls (Martin et al., 1965; Williams et al., 1975b) and beef-bred bulls (Bailey et al., 1966; Garrigus et al., 1969).

Wierbicki et al. (1956) reported DES treatment tended to produce slightly tougher meat at both 3 and 13 d postmortem due to more total connective tissue. Other studies (Kunkle et al., 1955; Cahill et al., 1956; Hedrick et al., 1969; Williams et al., 1975a) observed no sensory differences between samples obtained from control and DES-implanted bulls.

Ralgro. Improvements of 8 to 13% in growth rate and 8 to 10% in feed efficiency of steers and heifers have been attributed in several review articles to Ralgro (zeranol) implantation (Bennett et al., 1974; Hall, 1977; Scott, 1978; Thomas, 1979). Preston (1975) and Buttery et al. (1978) indicated zeranol was effective in promoting growth due to estrogen-like activity. Perry et al. (1970), reporting the results of six trials, found implanting Ralgro stimulated rate of gain of both steers and heifers under both growing and finishing conditions. The authors went on to say these results were comparable to those obtained from DES implantation. Sharp and Dyer (1971) concluded zeranol had a protein anabolic effect and delayed physiological maturity in steers, heifers and wether lambs.

Trial results using Ralgro in slaughter bulls are few and variable. Thiex and Embry (1972) observed little improvement in feedlot performance of bulls implanted at 10 mo of age and reimplanted 4 mo later with 36 mg of Ralgro. Embry (1972), using data from two trials, reported no appreciable effect on performance of yearling bulls implanted with a single 36-mg Ralgro implant. Improvements of 14% in body weight gain and 16% in feed conversion in slaughter bulls implanted at 212 kg and 107 d later with 36 mg of Ralgro were noted by Pasierbski et al. (1978). Gregory and Ford (1983) reported zeranol-implanted bulls gained

11% more during a 141-d period than nonimplanted males. The authors also noted zeranol-implanted intact males did not require less metabolizable energy or dry matter per kg gain than nonimplanted bulls. Vanderwert et al. (1983) observed no effect on bull growth rate due to zeranol implantation.

Gregory and Ford (1983) found zeranol treatment effects on carcass traits of feedlot bulls were of little consequence other than through weight. Similarly, no significant differences due to zeranol treatment have been demonstrated in steers (Sharp and Dyer, 1971; Borger et al., 1973b; Fontenot et al., 1973) and rams, wethers and ewes (Wilson et al., 1972). In contrast, Vanderwert et al. (1983) stated nonimplanted bulls and steers had higher marbling levels than zeranol-implanted bulls and steers.

Generally, no differences were found in the composition and palatability related characteristics of longissimus muscle samples of zeranol-implanted bulls and untreated intact males by Gregory et al. (1983). In contrast, Sharp and Dyer (1970) and Borger et al. (1973a) reported zeranol treatment significantly increased moisture percentage of longissimus muscle samples of steers. Borger et al. (1973a) also noted a significant decrease in lipid percentage of the longissimus muscle samples. Borger et al. (1973b) observed greater cooking losses for rib portions from implanted vs control steers and suggested this loss was primarily water.

Synovex Compounds. The active components of Synovex implants are natural hormones that are chemically identical to those produced by the animal's endocrine glands (Neumann, 1977). Synovex-H implants are recommended for heifers and consist of 200 mg testosterone propionate and 20 mg estradiol benzoate. Synovex-S implants, recommended for steers, consist of 200 mg progesterone and 20 mg estradiol benzoate. The components of these implants are absorbed, metabolized and eliminated from the body in the same manner as endogenous hormones of the animal.

Variable effects of testosterone propionate due to dosage level and sex of the animal were demonstrated in early work. Weekly injections of testosterone propionate (1 mg/kg body weight) were found to improve weight gain and feed conversion efficiency in both steers and heifers. However, heifers exhibited a greater response (Burris et al., 1952). Implantation of 180 mg and 75 mg testosterone propionate on d 0 and 96, respectively, decreased average daily gain and had no effect on feed efficiency of steers in work conducted by Andrews et al. (1954).

Respective Synovex implants have been shown to improve feedlot performance of steers and heifers in numerous studies (Ray et al., 1969; Dinius et al., 1976, 1978; Kahl et al., 1978; Rumsey, 1978). Several studies (Bradley et al., 1957; Wilson and Burdette, 1973; Koers et al., 1974a,b; Embry and Gates, 1976; Utley et al., 1976) have reported similar feedlot performance for cattle implanted with one of the Synovex compounds, DES or Ralgro.

Alteration of carcass traits are minimal due to Synovex implants. Koers et al. (1974a,b) and Utley et al. (1976) found carcass traits did not differ due to hormonal implant. Embry and Gates (1976) reported differences in carcass characteristics were small between implanted and nonimplanted steers, but implanted cattle tended to have slightly more subcutaneous fat, larger longissimus muscle area and less marbling and kidney fat. A slight increase in longissimus muscle area and a slight decrease in marbling level and quality grade in steers and heifers due to Synovex implants were noted by Stout (1980).

Little difference between samples of control and treated animals in cooking and palatability characteristics have been found in testosterone-treated steers and heifers (Burris et al., 1952) and Synovex-implanted steers and heifers (Stout, 1980).

Very few studies have been conducted using implants derived from naturally-occurring hormones in slaughter bulls. Forrest (1968) and Preston et al. (1975) concluded Synovex implants available for steers and heifers would not enhance growth rate, feed efficiency or lean content of young feedlot bulls. However, Forrest (1968, 1978) observed a small but nonsignificant increase in fat deposition due to hormone treatment in young bulls. Therefore, Forrest (1968) recommended young bulls reared for meat production be implanted with hormones since these hormones increased the deposition of fat to a more desirable level without decreasing rate of gain.

Sensory evaluation results of meat obtained from Synovex-implanted bulls are inconclusive. Forrest (1975) reported no significant differences as a result of hormone treatment for any of the organoleptic traits. In contrast, Stout (1980) and R. C. Johnson, W. J. Costello and D. H. Gee (unpublished data) have found Synovex-S implants improve taste panel juiciness and tenderness ratings. No explanation for the improved juiciness scores was offered in either study. Due to the high correlation (r = .76) between taste panel tenderness and low amounts of connective tissue, Stout suggested samples from implanted bulls were more tender because the exogenous hormones altered development of muscle connective tissue.

Growth, Carcass and Palatability Characteristics of Bulls vs Steers

Review articles assessing the differences between bulls and steers generally have indicated the intact male possesses advantages over his castrated counterpart in terms of feedlot performance and lean meat production (Cahill, 1964; Hedrick, 1968; Rhodes, 1969a; Field, 1971; Seideman et al., 1982). Numerous reports have shown bulls to possess at least a 15% advantage in average daily gain (Cahill, 1964; Robertson et al., 1969; Turton, 1969; Field, 1971; Jacobs et al., 1975a,b) and at least a 10% advantage in feed efficiency (Field, 1971; Jacobs et al., 1975a,b). Even wider differences in feed efficiency were found by Bidart et al. (1970) when feed consumed was expressed in gain of edible product. Their results showed that bulls consumed 6.0 Mcal digestible energy per kg of edible product compared to 12.8 Mcal for steers.

Hedrick (1968) concluded the differences in daily gain, due to sex, appeared to be consistent regardless of breed, type, age or weight for a given group. Price and Yeates (1969) reported the growth rate advantage of intact males up to puberty was small (0 to 5%); but, with the increased androgen production at puberty, a potential for high growth rate was established. The superiority of the intact male with regard to growth rate and feed efficiency was more strongly expressed on a higher plane than on a lower plane of nutrition (Cobic, 1968; Harte, 1969; Price and Yeates, 1969).

Nygaard et al. (1971) found bulls required fewer number of days on feed (366 vs 411) and less feed (6.67 vs 7.89 kg feed/kg gain) to reach the 475-kg endpoint than steers. Arthaud et al. (1977) observed that bulls fed to several ages (12, 15, 18 and 24 mo) made faster gains on less feed per unit of gain and produced carcasses with lower fat percentages than steers.

The redistribution of body fat and increased body musculature are two of the most important characteristics of the mature male. Ntunde et al. (1977), using Holstein-Friesian cattle fed to 7.0 mm fat thickness, reported bulls required more days on feed to reach fat thickness endpoint but yielded significantly heavier carcasses that contained less trimmable fat and a higher lean to fat ratio than steers. Bidart et al. (1970) concluded intact and castrated males did not differ in energetic efficiency, since the fraction of the total digestible energy consumed per day retained as calories of gain was the same (.123) for the two groups. However, intact males produced 20% more weight of protein$\cdot$day$^{-1}\cdot$unit of digestible energy consumed$^{-1}$ than did castrate males. This gain was associated with a positive nitrogen balance which has been ascribed to the protein anabolic effects of testicular hormones (Galbraith et al., 1978).

Nichols et al. (1964), Bailey et al. (1966), Jacobs et al. (1977a), Landon et al. (1978), Berry et al. (1978) and Johnson et al.

(1983) reported steers have more subcutaneous fat, less longissimus muscle area and more kidney fat than bulls. Due to less external fat (9.3 vs 14.3 mm), Field (1971) stated it was reasonable to expect bulls to have a lower dressing percentage than steers. However, numerous studies (Hedrick, 1968; Rhodes, 1969a; Field, 1971; Jacobs et al., 1975a) have indicated there were no major differences in dressing percentage between bulls and comparable steers. Hedrick (1968) concluded factors other than sex have a greater influence on dressing percentage. Smith (1982) stated more muscular bullocks can dress as high as fatter steers since dressing percentage is higher as animals increase in either muscling or fatness.

Bidart et al. (1970) found intact males produced 38% more edible product per unit of digestible energy consumed than castrate males. This difference was the result of both reduced digestible energy required per unit of carcass weight gain and increased percentage of edible product in carcasses of intact males. Jacobs et al. (1977a) reported intact Hereford males produced about 16% more edible meat than castrated males when slaughtered at about 18 mo of age.

Although results vary in magnitude, the literature indicates bulls possess an advantage over steers in carcass cutability. Hedrick (1968) concluded bulls would yield more meat than steers when compared on a major cut or total carcass basis because bulls have less finish. In a summary of five studies using the Murphey et al. (1960) estimating equation, Field (1971) reported bulls had a 2.6 percentage point advantage in yield of boneless round, loin, rib and chuck over steers.

However, Champagne et al. (1969), Gorstema et al. (1974) and Jacobs et al. (1977a) found differences of over 9% between bulls and steers using actual cutout data. Aware of these results, Cross and Allen (1982) stated it was difficult to determine if the need for using different prediction equations for estimating composition of bulls was due to differences in sex or to the lack of variation in outside fat in the bull carcass.

An unweighted mean of differences in either the percentage of separable lean or of boneless, closely trimmed retail product, reported from four experiments involving intact and castrated males, indicated an advantage of 5.1% for intact relative to castrated males (Field, 1971). Jacobs et al. (1975a) summarized three trials and concluded intact male carcasses yielded 15% more retail cuts than steer carcasses. When expressed as either a percentage of the carcass weight or kg of retail cuts per day of age, Landon et al. (1978) reported total retail cuts were greater for bulls than for steers.

Jacobs et al. (1977a) reported bull carcasses yielded 5.5% more boxed beef than steers, and cutting trim waste was 17% less than in steers. In addition, in-store retail yields showed bulls were higher in retail yield and worth approximately 15% more to the retailer than steers.

Numerous studies (Field, 1971; Jacobs et al., 1977a; Landon et al., 1978; Berry et al., 1978; Johnson et al., 1983) have reported bulls have less marbling and lower USDA quality grades than steers. In the first year of a 3-yr study, Jacobs et al. (1975a) found bulls graded high good compared to low choice for steers. In the second year, bulls were low good and steers low choice. Lower quality grades for bulls were partially due to a shorter time on the finishing diet, about 6 wk less than the steers. In the third year, longer time on the finishing diet improved the quality grades for bulls, but they were still below the quality grades for steers.

Bull carcasses were more mature physiologically on the basis of bone ossification and lean color than carcasses from steers of the same chronological age (Glimp et al., 1971). Similarly, Reagan et al. (1971) reported carcasses from steers were more youthful than carcasses from bulls of comparable chronological age. However, bone ossification was the primary factor affecting maturity evaluation in steer carcasses, while lean color was the major factor affecting variation in maturity scores for bull carcasses. Sex by chronological age interactions were observed by Arthaud et al. (1977) for secondary sex characteristics and physiological maturity. At 12 mo of age, differences between bulls and steers in thoracic, lumbar and sacral cartilage ossification were negligible; but, at older ages, bull carcasses consistently exhibited more advanced maturity.

Reports by Field (1971), Jeremiah (1978) and Price and Tennessen (1981) have indicated meat from bulls was darker in color and coarser in texture than meat from steers. Weninger and Steinhauf (1968) and Watson (1969) found the myoglobin level in bulls and steers to be similar. Field (1971) suggested bulls may be more easily stressed than steers because of their temperament and are possible candidates for dark-cutters.

After controlled preslaughter conditions, no differences in color were usually reported (Rhodes, 1969b). Price and Tennessen (1981) noted mixing and regrouping of strange bulls together increased the incidence of dark-cutting muscle (2 vs 73%). From their results, Price and Tennessen concluded the most disturbing part of the marketing process for bulls was not the unfamiliar surroundings or handling procedures but the presence of unfamiliar bulls.

In all studies summarized in a literature review by Field (1971), meat obtained from bulls was less tender when compared with meat from steers. Other studies (Glimp et al., 1971; Albaugh et al., 1975; Forrest, 1975; Arthaud et al., 1977; Ntunde et al., 1977; Stout, 1980) have also reported bull meat was slightly less tender than steer meat, but bull meat had acceptable tenderness ratings. Klosterman et al. (1954) noted only slight differences in tenderness between bulls and steers slaughtered at a relatively young age. Minimal differences in tenderness between bulls and steers slaughtered at 13 mo of age were observed by Brown et al. (1962) and Lewis et al. (1965). Hedrick et al. (1969) reported sensory panel scores and Warner-Bratzler shear force values indicated steaks from bulls less than 16 mo of age were comparable in tenderness to steaks from steers of similar age, whereas steaks from more mature bulls were less tender. Results obtained by Adams and Arthaud (1963), Wipf et al. (1964) and Field et al. (1965) have suggested an age gradient may exist in quality factors of bulls. Hunsley et al. (1971) concluded sex and chronological age may have a more adverse effect on tenderness in bull beef than in steer beef.

In contrast, Reagan et al. (1971) reported that steaks from bulls 385 d of age were less tender than steaks from steers of the same age. However, this difference was not as obvious between steaks from bulls and steers that were 484 d of age. It was apparent in this study that steaks from bull carcasses were considerably more variable in palatability than those from steer carcasses.

Experimental results of Crouse et al. (1983) suggested the variation in tenderness associated with sex condition was related to the connective tissue component of meat rather than the myofibrillar component. Boccard et al. (1979) reported the collagen content of muscle was higher in bulls than in steers regardless of age and collagen solubility decreased markedly between 12 and 16 mo of age in bulls. Boccard and co-workers speculated the increase in collagen in bulls between 8 and 12 mo of age was concomitant with sexual development and may be subject to some endocrine function in the animal. Cross et al. (1982) also found bulls were different than steers in regard to synthesis of intramuscular collagen at or near puberty and postulated the increased synthesis of collagen was influenced by testosterone or some related endocrine parameter.

Field (1971), Glimp et al. (1971), Albaugh et al. (1975), Arthaud et al. (1977), Ntunde et al. (1977) and Stout (1980) reported flavor, juiciness and overall acceptability were not significantly affected by sex condition. Reagan et al. (1971) noted steaks from steer carcasses were scored significantly more desirable in flavor than steaks from bull carcasses. Forrest (1975) found rib roasts from bulls (less than 15 mo) less juicy, less flavorful and lower in overall palatability scores than roasts from steers.

Chronological age did not seem to influence the flavor and juiciness scores of steaks from bulls in studies conducted by Hedrick et al. (1969) and Arthaud et al. (1977). Field et al. (1966) reported flavor and juiciness scores were not affected significantly by age of bulls when marbling was held constant, but roasts from older bulls were generally scored lower. Reagan et al. (1971) indicated steaks derived from bulls may acquire undesirable flavor traits between the ages of 385 and 484 d of age.

<u>Breed Effects on Carcass Composition and Palatability</u>

Ramsey et al. (1963) conducted a study comparing the cooking losses and palatability differences among breeds of British, Zebu and dairy-type cattle fed and managed under similar conditions. Among breeds, they reported total cooking losses did not parallel external fatness, and shear values were found to substantiate taste panel tenderness relationships. The carcass traits of these cattle (Cole et al., 1963) indicated Angus steer carcasses had the most marbling and graded the highest of all breeds. However, Angus steaks generally were rated lower in palatability than steaks from Jerseys and Herefords. Ramsey et al. (1963) concluded factors other than marbling may play an important role in determining eating quality.

Glimp et al. (1971) found carcasses from Hereford males were generally leaner than Angus carcasses, having a lower fat thickness, less estimated percentage kidney fat and a higher estimated percentage cutability. Angus carcasses were noted to have higher quality grades, due primarily to higher marbling scores. These differences in marbling scores were substantiated by ether-extractable fat percentages of the longissimus muscle. The authors also noted Angus steaks were more tender as measured by both the Warner-Bratzler shear and trained taste panelists and were higher in overall acceptability. Breed effects on flavor and juiciness were not rated significantly different by the taste panel.

Carcass characteristics of young bulls from Angus, Hereford and Holstein dams and Angus, Hereford, Brown Swiss, Charolais and Shorthorn sires were reported by Fredeen et al. (1972). Results indicated dressing percentage was not influenced by breed of dam or sire. Longissimus muscle area was affected by breed of dam but not breed of sire. British breed crosses were found to have the greatest rib fat depth and Holstein, Brown Swiss and Charolais crosses the least. Total deboned-defatted lean yield of the carcass was least for the British breed crosses. Although the British breed crosses showed the greatest degree of marbling, results indicated the breed crosses did not differ in longissimus muscle ether extract values. Freedeen and associates went on to show there were no breed of dam or breed of sire differences in tenderness of the longissimus muscle, either by Warner-Bratzler or taste panel evaluation, but significant breed of sire-breed of dam interactions were evident for these traits.

The cooking losses and eating quality of semitendinosus and M. longissimus roasts from young bulls representing five breed groups fed and managed similarly were reported by Hawrysh and Berg (1975). Cooking losses for both roasts were not affected by breed. Sensory evaluation indicated semitendinosus and M. longissimus roasts from all animals were generally similar, and objective measurements of juiciness and tenderness supported the sensory evaluations. Although some differences in palatability were determined, Hawrysh and Berg concluded all the beef was acceptable and the differences were not large enough to be of practical significance.

Berg and Butterfield (1976) as cited by Kogel and Alps (1978) suggested the correlation between muscle and fat could be an indicator of the rate of maturity because the development of fat in relation to other tissues increases faster after a certain stage of maturity than the growth of muscle. Kogel and Alps summarized the characteristics of 1,028 carcasses of Continental European breeding and found a negative correlation between muscle and fat for straightbred Gelbvieh and Simmental x Pinzgauer bulls. These results indicated the straightbred Gelbvieh and Simmental x Pinzgauer bulls could have been fed to a higher weight without producing carcasses with too much fat.

The relationship of breed, sex and animal age with shear force of cooked meat and pigment iron content was reported by Boccard et al. (1979). Results implied collagen solubility has a greater effect on shear force values than content of muscle collagen. Collagen characteristics were reported to be linked to the sexual maturity of the two breeds. Muscle pigment content of the two breeds was not different at birth and 24 mo of age. However, muscle pigment levels were seen to increase at different rates during the 24-mo period.

Koch et al. (1979) investigated the composition and quality characteristics of 775 steer carcasses obtained from various breed matings. Breed groups were reported as differing significantly in growth rate of fat, lean and bone. The average live weight at which breed groups reached 18.9% fat trim, on a carcass basis, ranged from 400 to 661 kg. At equal fat trim percentages, significant differences in marbling were found, but only small differences in percentage retail product or bone were observed, indicating only slight differences in muscle-to-bone ratio among breed groups. Differences in composition were shown to be greatest at a constant weight. Growth rate of breed groups and percentage retail product and bone were found to be positively associated. Koch and associates went on to show taste panel evaluation of a subset of 377 carcasses revealed breed groups differed significantly in tenderness. However, all groups were scored in the range of moderately tender. Sire breed groups were reported as not differing in juiciness or flavor. Their results indicated differences in palatability among breed groups were small in animals of similar age raised under similar feeding and management conditions.

Winer et al. (1981) investigated the palatability of rib steaks from 400-d-old straightbred and crossbred bullocks from eight mating combinations. Overall breed type effects on color, tenderness, desirability and Warner-Bratzler shear test of unaged longissimus muscle were found to be nonsignificant. Significant breed type variation was observed in flavor and juiciness. Adjunct studies of longissimus muscle from steaks frozen 2 d postmortem vs steaks aged for an additional 14 d after vacuum packaging indicated samples aged for the longer period were more desirable in all palatability characteristics. Breed type effects on palatability characteristics of aged longissimus muscles were reported as nonsignificant.

Gregory et al. (1983) reported differences in composition and palatability characteristics of a first generation composite population of one-fourth each of Angus, Hereford, Simmental and Gelbvieh (MARC II) and straightbred populations of Charolais and Limousin. Breed groups were found to differ significantly in longissimus muscle composition, marbling score and in sensory panel scores for tenderness, amount of connective tissue and ease of fragmentation. Even though differences between breed groups were significant for several of the traits evaluated by the sensory panel, the authors concluded these differences were too small to be important.

Vanderwert et al. (1983), reporting on a study comparing the growth and carcass characteristics of Angus and Limousin cattle, found Limousins had greater longissimus muscle areas but required more days on feed to reach the desired fat endpoint. Marbling scores and Warner-Bratzler shear values were shown to favor the Angus.

# INTRODUCTION

The ideal type of beef animal for the present and for the future is an animal that has inherent potential for efficiently converting feed grains and roughages into the maximum amount of consumer acceptable meat possible (Hedrick, 1972). Gregory (1982) suggested, if feed resources and management were such that it was feasible to leave one-half of the male cattle produced intact, the expected increase in retail product weight would be 9.5% from the same number of cows and the same feed resources. Consumer concern for price and nutrient density of their beef purchases has shifted consumer demand to lean beef that contains a minimal amount of waste fat. Jacobs et al. (1977a,b) reported bulls produced carcasses that yielded 17% less trim waste and were 15% more valuable to the retailer than steer carcasses.

Although the production efficiency advantage of intact males is well known, strong resistance in traditional marketing channels has been encountered. Research has shown young bull (bullock) beef to be slightly less tender and more variable in palatability than steer beef (USDA, 1975). At the retail level, bullock beef is believed to have lower consumer appeal than steer beef because of differences in color, texture and fat deposition (Seideman et al., 1982).

The effects of anabolic agents currently available for steers and heifers have been studied in only a limited number of experiments involving intact males. In two such studies (Stout, 1980; R. C. Johnson, W. J. Costello and D. H. Gee, unpublished data), improved juiciness and tenderness ratings have been attributed to Synovex-S implants. Although

Forrest (1968, 1975) did not observe any significant improvements in the desirability of rib roasts due to implantation, he recommended that young bulls reared for meat production be implanted with hormones, since a more desirable level of fat deposition was observed without decreasing feedlot performance.

The objectives of this experiment were to assess the effects of three currently available implants (Ralgro, Synovex-H and Synovex-S) and two breed groups (straightbred Angus and crossbred Gelbvieh) on the carcass traits and palatability characteristics of bullock beef.

# MATERIALS AND METHODS

A total of 199 young bulls from two breed groups were assigned to four experimental treatments as follows: (1) nonimplanted, (2) implanted at d 0 and 100 with 36 mg zeranol (Ralgro), (3) implanted at d 0 and 100 with 200 mg testosterone propionate and 20 mg estradiol benzoate (Synovex-H) and (4) implanted at d 0 and 100 with 200 mg progesterone and 20 mg estradiol benzoate (Synovex-S). Average initial weight on experiment was 247 kg. Breed groups included in the experiment were straightbred Angus (99 head, one source) and Gelbvieh crossbreds (100 head, two sources).

Each treatment by breed group was penned and fed separately in outside dirt mound lots with fence-line bunks at the Southeast South Dakota Experiment Farm, Beresford. During the course of the study, one Angus bull was removed from the study and one Angus and two Gelbvieh bulls died. Further detail of the experimental design is provided in table 1.

The diet fed for the first 100 d of the study was, on a dry matter basis, 25% corn (IFN 4-02-919), 70% corn silage (IFN 3-08-152) and 5% protein-mineral-vitamin supplement that was composed primarily of soybean oil meal (IFN 5-04-600). The diet fed for the remainder of the experiment (Angus $\bar{x}$ = 101 d, Gelbvieh $\bar{x}$ = 129 d) was, on a dry matter basis, 86% corn, 5% alfalfa hay (IFN 1-08-877), 4% corn cobs (IFN 1-02-782) and 5% protein-mineral-vitamin supplement. Diets were fed ad libitum throughout the experiment.

TABLE 1. NUMBER OF ANIMALS BY TREATMENT AND BREED GROUP[a]

| Breed group | Treatment: Non-implanted | Ralgro[b] | Synovex-H[b] | Synovex-S[b] | Total |
|---|---|---|---|---|---|
| Angus | 25 (25) | 25 (25) | 24 (24) | 25 (23) | 99 ( 97) |
| Gelbvieh | 25 (24) | 25 (25) | 25 (24) | 25 (25) | 100 ( 98) |
| Total | 50 (49) | 50 (50) | 49 (48) | 50 (48) | 199 (195) |

[a] Slaughter numbers for treatment, breed and treatment by breed groups are indicated in parentheses.
[b] Implanted on d 0 and 100.

Animals were slaughtered at a commercial packing company at the conclusion of the feedlot period and hot carcass weights were obtained. Carcass data were collected approximately 24 h postmortem with the assistance of a USDA grader. Data provided by the grader consisted of marbling and maturity scores, final quality grades, adjusted subcutaneous fat thickness and estimated percentage kidney, pelvic and heart fat. Longissimus muscle perimeter was traced at the 12th rib interface and a compensating polar planimeter was later used to determine area.

The 9th to 12th rib portion of the right wholesale rib of 10 randomly selected carcasses from each treatment by breed group were transported to the South Dakota State University Meat Laboratory and aged at 10 C. The longissimus muscle was removed from each rib section 14 d postmortem, wrapped in polyethylene-coated freezer paper and frozen at -20 C. Within 30 d postmortem, the caudal end of each longissimus muscle was faced and three steaks (3.5, 1.5 and 2.5 cm thick) were sequentially removed and designated for Warner-Bratzler shear, chemical and taste panel analyses, respectively. All steaks were wrapped, labeled and stored at -20 C for no more than 3 mo. When needed for analysis, steaks were thawed 24 h at 2 C.

Steaks for sensory evaluation were cooked on Farberware Open Hearth broilers to an internal temperature of 70 C as monitored by copper constantan thermocouples placed in the geometric center of each steak. Cooking time was recorded and percentage cooking loss was calculated. Degree of doneness (1 = very rare, 3 = medium rare and 5 = well done) was assigned to each cooked steak using photographic standards (NLS & MB, 1979). A 1.3-cm cube from each steak was evaluated by each participant of a nine-member experienced sensory panel for juiciness, tenderness, connective tissue amount, flavor desirability and overall desirability using an eight-point scale for each factor (1 = extremely dry, extremely tough, abundant or extremely undesirable; 8 = extremely juicy, extremely tender, none or extremely desirable, respectively). Taste panel participants were not trained and screened specifically for this experiment. However, all panelists had previously participated in similar panels.

Shear force measurements were made after thawing and cooking steaks by the same procedure used for the sensory panel evaluations. Cooking time was also recorded. After allowing the steak to cool to room temperature, two 2.5-cm cores were taken from each steak perpendicular to the steak surface with a drill press unit and sheared parallel to the steak surface in a Warner-Bratzler shear apparatus.

The longissimus muscle of the second steak was trimmed of all external fat and epimysial connective tissue, cut into cubes, frozen in liquid nitrogen and pulverized in a Waring blender. Fat and moisture percentages of the longissimus muscle were determined by ether-extract and oven-drying. Longissimus muscle protein percentage was determined by difference.

Statistical analyses were performed by least-squares analyses of variance outlined by Steel and Torrie (1980). When significant differences were detected among treatment means, differences between means were determined by Waller-Duncan K-ratio t-test and least significant difference for equally and unequally replicated means, respectively. Simple correlation coefficients were calculated for the carcass and laboratory traits evaluated.

# RESULTS AND DISCUSSION

## Carcass Traits

Least-squares means and their standard deviations for carcass traits are presented in table 2 by treatment and breed group. The interaction of treatment by breed group was not significant for any of the carcass traits observed.

The effects of treatment were significant for fat thickness and USDA yield grade (table 2). The Synovex-implanted groups were fatter ($P<.01$) than the nonimplanted group, while fat thickness of the Ralgro group was intermediate. Previous studies (Forrest, 1968, 1978; Stout, 1980; Johnson et al., 1983; Paterson et al., 1983; R. C. Johnson, W. J. Costello and D. H. Gee, unpublished data) have only indicated a tendency for Synovex-S implants to increase carcass fatness of young bulls. The lack of difference in fat thickness of nonimplanted and Ralgro-implanted intact males was consistent with results obtained by Gregory and Ford (1983). However, Gray et al. (1983) reported a tendency for fat thickness to be increased in bulls when implanted with Ralgro from birth to slaughter or from weaning to slaughter.

Carcass cutability, as indicated by USDA yield grade, of the nonimplanted, Ralgro and Synovex-H groups were comparable due to the compensatory effects of longissimus muscle area and fat thickness. Similarly, Gregory and Ford (1983) reported the alteration of estimated carcass cutability of intact males could not be attributed to the use of Ralgro implants. In contrast to the results of the current study,

TABLE 2. LEAST-SQUARES MEANS AND STANDARD DEVIATIONS FOR CARCASS TRAITS BY TREATMENT AND BREED GROUP

| Item | No. of observations | Hot carc. wt, kg | Longissimus muscle area, $cm^2$ | Fat thickness, mm | Est. KPH fat, %[a] | USDA yield grade[b] | Maturity score[c] | Marbling score[d] | USDA quality grade[e] |
|---|---|---|---|---|---|---|---|---|---|
| Treatment | | | | | | | | | |
| Level of significance[f] | | NS | NS | ** | NS | ** | NS | NS | NS |
| Nonimplanted | 49 | 331 | 84.6 | 7.5[h] | 1.9 | 2.2[h] | 5.0 | 7.1 | 4.3 |
| Ralgro[g] | 50 | 337 | 87.7 | 8.4[hi] | 1.7 | 2.1[h] | 4.9 | 6.5 | 4.0 |
| Synovex-H[g] | 48 | 335 | 85.8 | 9.3[i] | 1.9 | 2.3[hi] | 4.9 | 7.1 | 4.4 |
| Synovex-S[g] | 48 | 344 | 85.2 | 9.7[i] | 2.0 | 2.5[i] | 4.9 | 7.1 | 4.4 |
| Breed group | | | | | | | | | |
| Level of significance | | ** | ** | ** | NS | ** | * | ** | ** |
| Angus | 97 | 322 | 81.6 | 12.4 | 1.9 | 2.8 | 5.0 | 8.5 | 5.5 |
| Gelbvieh | 98 | 352 | 90.0 | 5.1 | 1.8 | 1.9 | 4.9 | 5.5 | 3.1 |
| Standard deviation | | 28.3 | 8.72 | 2.87 | .59 | .56 | .32 | 1.74 | 1.30 |

[a] Estimated kidney, pelvic and heart fat.
[b] Objective estimation of boneless, closely trimmed retail cuts: yield grade 1.5 = 53.5%, 2.0 = 52.3%.
[c] 6 = A-, 5 = $A^{o}$, 4 = A+, 3 = B-, 2 = $B^{o}$, 1 = B+.
[d] 10 = small -, 7 = slight -, 4 = traces -.
[e] 7 = choice -, 4 = good -, 1 = standard -.
[f] NS = not significant.
[g] Implanted on d 0 and 100.
[h,i] Treatment means within a column bearing a common superscript do not differ (P<.01).
* P<.05.
** P<.01.

Paterson et al. (1983) noted a tendency for Synovex-H implants to increase USDA yield grades in Gelbvieh crossbred bulls when compared to nonimplanted bulls.

The Synovex-S group had a higher (P<.01) USDA yield grade than the nonimplanted group, primarily because of the fat thickness difference. Johnson et al. (1983) and R. C. Johnson, W. J. Costello and D. H. Gee (unpublished data) obtained similar results from the use of Synovex-S implants on intact males. However, only Johnson et al. (1983) found a significant effect. The difference (P<.01) in USDA yield grade between the Ralgro and Synovex-S groups was due to the additive effect of the longissimus muscle area and fat thickness differences.

The effects of breed group were significant for most of the carcass traits evaluated (table 2). Results from this study are interpreted to indicate Gelbvieh crossbred bulls had leaner carcasses than Angus bulls. Even though hot carcass weight was greater (P<.01) for the Gelbvieh carcasses, the Gelbvieh breed group had a lower (P<.01) USDA yield grade due to lower (P<.01) 12th rib fat thickness and larger (P<.01) longissimus muscle area.

Angus carcasses had higher (P<.01) USDA quality grades than Gelbvieh crosses, due primarily to higher (P<.01) marbling scores. Although the Angus breed group received a younger (P<.05) maturity score, this difference was not important from a practical standpoint since all carcasses received A maturity scores and were therefore eligible for USDA bullock quality grades (USDA, 1975).

The carcass composition and quality relationships observed between straightbred Angus and Gelbvieh crossbreds were in agreement with results reported by Koch et al. (1979) in an evaluation of several breed groups of steers. They found Gelbvieh crosses, when compared to straightbred Angus, were leaner when adjusted to either a common age or carcass weight and heavier muscled when adjusted to a common age, carcass weight, fat thickness, fat trim percentage or marbling score. In addition, Koch and associates suggested the eight breed groups evaluated could be divided into two classes based on USDA yield grade, with the Gelbvieh crosses in one class and the straightbred Angus in the other. Straightbred Angus were also reported to have higher marbling scores than Gelbvieh crossbreds at all endpoints (age, carcass weight, fat thickness or fat trim percentage).

Meat Traits

Least-squares treatment and breed group means and their standard deviations for taste panel evaluation, Warner-Bratzler shear force and longissimus muscle chemical composition are presented in table 3. While the interaction of treatment by breed group was significant for moisture in the longissimus muscle, this interaction did not lend itself to a logical explanation.

The effects of treatment were nonsignificant for traits associated with taste panel evaluation and Warner-Bratzler shear force (table 3). Previous studies of sensory characteristics of meat obtained from bulls implanted with growth stimulants have been

TABLE 3. LEAST-SQUARES MEANS AND STANDARD DEVIATIONS FOR MEAT TRAITS BY TREATMENT AND BREED GROUP

| Item | No. of obser- vations | Cooking time, min | Cooking loss, % | Taste panel evaluation: Degree of doneness score[a] | Taste panel evaluation: Juici- ness score[b] | Taste panel evaluation: Tender- ness score[c] | Taste panel evaluation: Amount of connective tissue score[d] | Taste panel evaluation: Flavor desira- bility score[e] | Taste panel evaluation: Overall desira- bility score[e] | Warner- Bratzler shear force, kg/2.5 cm | Marb- ling score[f] | Longissimus muscle composition: Fat, % | Longissimus muscle composition: Water, % | Longissimus muscle composition: Protein, % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | | | | | | | | | | | | | | |
| Level of significance[g] | | NS | NS | NS | NS | NS | NS | NS | NS | NS | * | * | ** | NS |
| Nonimplanted | 20 | 27.6 | 26.0 | 3.8 | 4.9 | 5.0 | 5.3 | 5.0 | 4.9 | 9.2 | 6.9[ij] | 2.8[i] | 74.1[i] | 23.1 |
| Ralgro[h] | 20 | 25.9 | 24.7 | 3.8 | 5.1 | 5.2 | 5.2 | 5.0 | 5.0 | 9.3 | 6.0[i] | 2.1[i] | 74.5[i] | 23.4 |
| Synovex-H[h] | 20 | 26.7 | 24.8 | 3.5 | 5.1 | 4.9 | 5.1 | 5.1 | 5.0 | 9.3 | 7.0[ij] | 2.6[i] | 74.0[i] | 23.3 |
| Synovex-S[h] | 20 | 28.1 | 26.1 | 3.6 | 5.2 | 4.7 | 4.9 | 5.1 | 5.0 | 9.8 | 7.7[j] | 3.2[j] | 73.5[j] | 23.3 |
| Breed group | | | | | | | | | | | | | | |
| Level of significance | | NS | NS | NS | NS | ** | ** | NS | * | ** | ** | ** | ** | ** |
| Angus | 40 | 27.1 | 25.4 | 3.8 | 5.1 | 5.2 | 5.3 | 5.1 | 5.1 | 8.9 | 8.4 | 3.2 | 73.7 | 23.1 |
| Gelbvieh | 40 | 27.0 | 25.4 | 3.5 | 5.1 | 4.7 | 4.9 | 5.0 | 4.8 | 9.9 | 5.4 | 2.1 | 74.4 | 23.5 |
| Standard deviation | | 5.66 | 4.37 | .63 | .62 | .78 | .69 | .45 | .64 | 1.42 | 1.75 | 1.04 | .81 | .58 |

[a] 6 = very well done, 5 = well done, 4 = medium, 3 = medium rare, 2 = rare, 1 = very rare.

[b] 8 = extremely juicy, 7 = very juicy, 6 = moderately juicy, 5 = slightly juicy, 4 = slightly dry, 3 = moderately dry, 2 = very dry, 1 = extremely dry.

[c] 8 = extremely tender, 7 = very tender, 6 = moderately tender, 5 = slightly tender, 4 = slightly tough, 3 = moderately tough, 2 = very tough, 1 = extremely tough.

[d] 8 = none, 7 = practically none, 6 = traces, 5 = slight, 4 = moderate, 3 = slightly abundant, 2 = moderately abundant, 1 = abundant.

[e] 8 = extremely desirable, 7 = very desirable, 6 = moderately desirable, 5 = slightly desirable, 4 = slightly undesirable, 3 = moderately undesirable, 2 = very undesirable, 1 = extremely undesirable.

[f] 10 = small −, 7 = slight −, 4 = traces −. For those carcasses from which laboratory evaluation steaks were obtained.

[g] NS = not significant.

[h] Implanted on d 0 and 100.

[i,j] Treatment means within a column bearing a common superscript do not differ ($P<.05$).

* $P<.05$.

** $P<.01$.

inconsistent. In agreement with results of the current study, Gregory et al. (1983) found no effect due to treatment on the palatability characteristics of meat derived from bulls first implanted with zeranol at 12 mo of age and slaughtered at 17 mo of age. In addition, Forrest (1975) reported no significant differences were evident in any of the organoleptic traits of bullock rib roasts as a result of Synovex-S treatment. In contrast, Corah (1980) indicated zeranol treatment of intact males resulted in a marked improvement in eating quality of meat when implanting was started at a young age. Stout (1980) and R. C. Johnson, W. J. Costello and D. H. Gee (unpublished data) have attributed improved taste panel juiciness and tenderness ratings to the use of Synovex-S implants in intact males. Stout hypothesized, due to the high relationship between taste panel scores for tenderness and low amounts of connective tissue ($r = .76$), the exogenous hormone treatment altered the development of connective tissue in intact males.

The nonsignificant effect of implant treatment on Warner-Bratzler shear values (table 3) was in agreement with earlier studies. Gregory et al. (1983) and Vanderwert et al. (1983) have indicated zeranol implantation had no effect on shear values. A small but nonsignificant increase in shear values of meat obtained from Synovex-S implanted bulls was found by Stout (1980) and R. C. Johnson, W. J. Costello and D. H. Gee (unpublished data). Paterson et al. (1983) reported no differences among shear values of meat obtained from Gelbvieh crossbred bulls that were not implanted or implanted twice with either Ralgro, Synovex-H or Synovex-S.

Marbling score least-squares means for the carcasses from which laboratory evaluation samples were obtained (table 3) were comparable to those of the entire slaughter group (table 2). However, the laboratory evaluated Ralgro group had a lower ($P<.05$) marbling score than the Synovex-S group. Fat and moisture percentages of the non-implanted, Ralgro and Synovex-H groups were not different, while the Synovex-S group had more ($P<.05$) fat and less ($P<.05$) water than the other three groups (table 3). Gregory et al. (1983) reported 36-mg implants of zeranol increased fat percentage and had no effect on water percentage of the longissimus muscle. In agreement with the present study, Johnson et al. (1983) reported the use of Synovex-S in intact males led to increased fat and decreased moisture percentages of the longissimus muscle. Paterson et al. (1983) found Ralgro, Synovex-H and Synovex-S groups had reduced moisture percentages when compared to a nonimplanted group, and the Synovex groups tended to have higher ether-extract values for the 11th rib soft tissue. In the current study, growth stimulating implants had no significant effect on protein percentages of the four treatment groups.

Differences between breed groups were significant for taste panel scores for tenderness, amount of connective tissue and overall desirability, Warner-Bratzler shear force, marbling score and longissimus muscle composition (table 3). Differences that were significant between breed groups for the sensory traits, shear force and marbling score all favored the Angus over the Gelbvieh crosses. Composition percentages of the longissimus muscle were interpreted to indicate the Gelbvieh breed group had less (P<.01) fat and more (P<.01) water and protein than the Angus.

Although the Angus breed group was favored in all taste panel evaluated traits, least-squares means for all sensory traits of both breed groups were desirable ($\bar{x} > 4.5$). These results are interpreted to indicate the subtle differences in palatability attributes perceived by a discriminating panel may not be detected by the average consumer. Differences among breed groups in meat palatability have been demonstrated to be small in steers (Koch et al., 1976, 1979) and intact males (Hawrysh and Berg, 1975; Winer et al., 1981; Gregory et al., 1983) where animals were of similar age and had been raised under similar management conditions.

The relative rankings of subjective marbling scores and fat percentages were generally in accord (table 3). However, fat percentages related with specific marbling levels were not in agreement with previous studies. Similar marbling levels were reported in bullock carcasses by Gregory et al. (1983), but slightly higher fat percentages were associated with the marbling levels. The traces and slight marbling levels were found to have much higher fat percentages by Rhee et al. (1982).

Correlation Coefficients Among Carcass and Meat Traits

Hot carcass weight and maturity score were the only carcass traits significantly related to the traits associated with taste panel evaluation. Hot carcass weight was related (P<.05) to taste panel steak cooking time, cooking loss and taste panel scores for juiciness, tenderness and amount of connective tissue (r = .23, .24, -.23, -.24 and -.25, respectively) but only tended to be related (P<.06) with taste panel overall desirability score (r = -.22). Maturity score was correlated (P<.05) with sensory panel scores for juiciness (r = .23), amount of connective tissue (r = .28) and overall desirability (r = .27). In addition, maturity score was the only carcass trait significantly related to Warner-Bratzler shear force (r = -.36). Taste panel flavor desirability score was not significantly related to any of the carcass traits evaluated. Less than 5% of the variation in any of the sensory traits and Warner-Bratzler shear force could be accounted for by carcass fat thickness, marbling score and USDA quality grade (r = -.21 to .20). Hot carcass weight and maturity score accounted for 4 to 12% of the variability in palatability characteristics and Warner-Bratzler shear force of bullock longissimus steaks. However, since all carcasses received A maturity scores and the variation of maturity scores was minimal, hot carcass weight appeared to be the best palatability predictor of bullock carcasses in this study.

Cooking loss of the taste panel steak was related (P<.01) to cooking time (r = .74) and degree of doneness score (r = .34). All palatability traits evaluated by the sensory panel were related (P<.01) to each other, with scores for tenderness and amount of connective tissue being the most highly associated (r = .90). Warner-Bratzler shear force was related (P<.01) with sensory scores for tenderness (r = -.53), amount of connective tissue (r = -.53) and overall desirability (r = -.41). Palatability traits and Warner-Bratzler shear force were not significantly associated with cooking time. Degree of doneness score of the taste panel steak was associated ($P<.05$) with taste panel juiciness score ($r = -.26$). Longissimus muscle fat percentage was related ($P<.05$) with taste panel tenderness score ($r = .26$), Warner-Bratzler cooking time and shear force ($r = -.22, -.23$) and highly associated ($P<.01$) with longissimus muscle water and protein percentages ($r = -.87, -.65$). Longissimus muscle protein was correlated ($P<.01$) with taste panel scores for tenderness ($r = -.33$) and amount of connective tissue ($r = -.33$).

In conclusion, breed group had a greater effect on the carcass characteristics and meat traits of bullock beef than any of the anabolic implants used. The lack of treatment by breed group interactions of practical significance suggested that breed groups are expected to respond similarly to the effects of anabolic agents on carcass composition and quality traits, longissimus muscle composition and palatability related traits. Synovex implants significantly increased subcutaneous fat deposition in both breed groups. However, only Synovex-S decreased bullock carcass cutability. Carcasses derived from the Gelbvieh breed group had a significant cutability advantage over the Angus breed group. Angus carcasses had significantly higher carcass quality characteristics. Steaks from the Angus breed group received significantly higher tenderness, lower connective tissue amount and higher overall desirability ratings. The high relationship between tenderness and low amounts of connective tissue implies that the stromal component of bullock beef may account for the variability in bullock beef tenderness. Therefore, additional investigations need to be conducted to further characterize the connective tissue of bullock beef and possibly alter the development of this stromal component of beef.

## SUMMARY

A total of 199 young bulls representing two breed groups with an average weight of 247 kg were assigned to four experimental treatments as follows: (1) nonimplanted, (2) implanted at d 0 and 100 with Ralgro, (3) implanted at d 0 and 100 with Synovex-H and (4) implanted at d 0 and 100 with Synovex-S. During the feedlot period, four bulls were removed from the study. At the conclusion of the feedlot period (Angus $\bar{x}$ = 201 d, Gelbvieh $\bar{x}$ = 229 d), 195 animals were slaughtered and carcass data collected. Treatment had no effect on hot carcass weight, longissimus muscle area, estimated KPH fat, maturity score, marbling score or USDA quality grade. The two Synovex groups were fatter ($P<.01$) than the nonimplanted group. Nonimplanted and Ralgro-implanted bulls had greater ($P<.01$) estimated carcass cutability than Synovex-S-implanted males. Breed groups differed significantly for all carcass traits evaluated except estimated KPH fat. Gelbvieh breed group possessed an advantage ($P<.01$) in estimated carcass cutability. Angus breed group had higher ($P<.01$) USDA quality grade due to higher ($P<.01$) marbling score. Although a significant maturity difference was observed between the two breed groups, this difference was not important from a practical standpoint since all carcasses received A maturity scores. Sensory and chemical composition evaluation of a subset of 80 carcasses revealed that treatment affected only chemical composition and breed group affected several of the sensory and chemical composition traits. Longissimus muscle samples of the Synovex-S group had more ($P<.05$) fat and less ($P<.01$) water than the other three treatment groups. Although

both breed groups received desirable scores for all palatability traits, breed group differences favored Angus over Gelbvieh crosses for taste panel scores for tenderness ($P<.01$), amount of connective tissue ($P<.01$) and overall desirability ($P<.05$). Angus bullock samples required less ($P<.01$) shear force than Gelbvieh crosses. Longissimus muscle composition percentages indicated the Gelbvieh had less ($P<.01$) fat and more ($P<.01$) water and protein than the Angus.

# LITERATURE CITED

Adams, C. H. and V. H. Arthaud. 1963. Influence of sex and age differences on tenderness of beef. J. Anim. Sci. 22:1112 (Abstr.).

Albaugh, A., F. D. Carroll, K. W. Ellis and R. Albaugh. 1975. Comparison of carcasses and meat from steers, short scrotum bulls and intact bulls. J. Anim. Sci. 41:1627.

Andrews, F. N., W. M. Beeson and F. D. Johnson. 1954. The effects of stilbestrol, dienesterol, testosterone and progesterone on the growth and fattening of beef steers. J. Anim. Sci. 13:99.

Andrews, F. N. and B. B. Bohren. 1947. Influence of thiouracil and stilbestrol on growth, fattening, and feed efficiency in broilers. Poul. Sci. 26:447.

Arthaud, V. H., R. W. Mandigo, R. M. Koch and A. W. Kotula. 1977. Carcass composition, quality and palatability attributes of bulls and steers fed different energy levels and killed at four ages. J. Anim. Sci. 44:53.

Bailey, C. M., C. L. Probert and V. R. Bohman. 1966. Growth rate, feed utilization and body composition of young bulls and steers. J. Anim. Sci. 25:132.

Baker, F. H. and V. H. Arthaud. 1972. Use of hormones or hormone active agents in production of slaughter bulls. J. Anim. Sci. 35:752.

Bennett, G., W. H. Beaumont and P. R. M. Brown. 1974. Use of the anabolic agent zearanol (resorcylic acid lactone) as a growth promoter for cattle. J. Vet. Rec. 94:235.

Berg, R. T. and R. M. Butterfield. 1976. New Concepts of Cattle Growth. Sydney Univ. Press.

Berry, B. W., A. L. Joseph, S. B. Wagner, T. G. Jennings, J. K. Matsushima, J. S. Brinks, J. A. Carpenter, Jr. and P. T. Fagerlin. 1978. Carcass, palatability and retail characteristics of steers and short scrotum bulls. J. Anim. Sci. 47:601.

Bidart, J. B., R. M. Koch and V. H. Arthaud. 1970. Comparative energy use in bulls and steers. J. Anim. Sci. 30:1019.

Blaxter, K. L. 1964. The efficiency of feed conversion by livestock. England J. Royal Agr. Soc. 125:87.

Boccard, R. L., R. T. Naude, D. E. Cronje, M. C. Smit, H. J. Venter and E. J. Rossouw. 1979. The influence of age, sex and breed of cattle on their muscle characteristics. Meat Sci. 3:280.

Borger, M. L., J. D. Sink, L. L. Wilson, J. H. Ziegler and S. L. Davis. 1973a. Zeranol and dietary protein level effects on DNA, RNA and protein composition of three muscles and the relationship to serum insulin and GH levels of steers. J. Anim. Sci. 36:712.

Borger, M. L., L. L. Wilson, J. D. Sink, J. H. Ziegler and S. L. Davis. 1973b. Zeranol and dietary protein level effects on live performance, carcass merit, certain endocrine factors and blood metabolite levels of steers. J. Anim. Sci. 36:706.

Bradley, N. W., G. E. Mitchell, Jr., W. W. Albert, A. L. Neumann and J. L. Williamson. 1957. Synovex and stilbestrol implants for wintering and fattening beef calves with reimplantation effects. J. Anim. Sci. 16:1032 (Abstr.).

Brown, C. J., J. D. Bartee and P. K. Lewis, Jr. 1962. Relationships among performance records, carcass cut-out data, and eating quality of bulls and steers. Arkansas Agr. Exp. Sta. Bull. 655.

Burris, M. J., R. Bogart, A. W. Oliver and A. Overman Mackey. 1952. The effect of testosterone propionate on rate of gain, feed efficiency, and carcass quality of beef heifers and steers. J. Anim. Sci. 11:789 (Abstr.).

Buttery, P. J., B. G. Vernon and J. T. Pearson. 1978. Anabolic agents - some thoughts on their mode of action. Proc. Nutr. Soc. 37:311.

Cahill, V. R. 1964. Effects of sex differences in beef carcasses relative to cutability and palatability. Proc. Recip. Meat Conf. 17:35.

Cahill, V. R., L. E. Kunkle, E. W. Klosterman, F. E. Deatherage and E. Wierbicki. 1956. Effect of diethylstilbestrol implantation on carcass composition and the weight of certain endocrine glands of steers and bulls. J. Anim. Sci. 15:701.

Casas, M. and N. S. Raun. 1964. Effect of stilbestrol implantation on feedlot bulls. J. Anim. Sci. 23:870 (Abstr.).

Champagne, J. R., J. W. Carpenter, J. F. Hentges, Jr., A. Z. Palmer and M. Koger. 1969. Feedlot performance and carcass characteristics of young bulls and steers castrated at four ages. J. Anim. Sci. 29:887.

Cobic, T. 1968. Castration experiments with Yugoslav Simmental cattle. I. The effect of castration on growth and live-weight gains. Anim. Prod. 10:103.

Cole, J. W., C. B. Ramsey, C. S. Hobbs and R. S. Temple. 1963. Effects of type and breed of British, Zebu and dairy cattle on production, palatability and composition. I. Rate of gain, feed efficiency and factors affecting market value. J. Anim. Sci. 22:702.

Corah, L. R. 1980. Commonly asked questions about implants. Coop. Ext. Service, Kansas State Univ. L-557.

Cross, H. R. and D. M. Allen. 1982. Future for beef from intact males--slaughter to retail. Presentation to Midwest Section, Amer. Soc. Anim. Sci., Chicago, IL. March 23, 1982.

Cross, H. R., B. D. Schanbacher and S. C. Seideman. 1982. The influence of age, breed and sex of beef cattle on the biosynthesis of muscle collagen. J. Anim. Sci. 55(Suppl. 1):236.

Crouse, J. D., S. C. Seideman and H. R. Cross. 1983. The effects of carcass electrical stimulation and cooler temperature on the quality and palatability of bull and steer beef. J. Anim. Sci. 56:81.

Dinius, D. A., H. K. Goering, R. R. Oltjen and H. R. Cross. 1978. Finishing beef steers on forage diets with additives and supplemental lipid. J. Anim. Sci. 46:761.

Dinius, D. A., H. K. Goering, R. R. Oltjen and T. S. Rumsey. 1976. Finishing steers on alfalfa hay or meal and additives. J. Anim. Sci. 43:319 (Abstr.).

Embry, L. B. 1972. Effect of sex, castration and hormonal compounds on feedlot performance and carcass merit of cattle. Proc. South Dakota Agr. Exp. Sta. Cattle Feeders Day Rep. pp 10-53.

Embry, L. B. and R. N. Gates. 1976. Diethylstilbestrol, zeranol or Synovex implants for finishing steers. J. Anim. Sci. 43:320 (Abstr.).

Field, R. A. 1971. Effect of castration on meat quality and quantity. J. Anim. Sci. 32:849.

Field, R. A., G. E. Nelms and C. O. Schoonover. 1966. Effects of age, marbling and sex on palatability of beef. J. Anim. Sci. 25:360.

Field, R. A., C. O. Schoonover and G. E. Nelms. 1965. Effects of age, marbling and sex on palatability of beef. J. Anim. Sci. 24:862 (Abstr.).

Fontenot, J. P., R. F. Kelly and K. E. Webb, Jr. 1973. Zeranol implants in grazing and fattening steers. J. Anim. Sci. 36:217 (Abstr.).

Forrest, R. J. 1968. Effect of exogenous hormones on the production of beef from Holstein-Friesian steers and bulls reared from birth to 475 kilograms on all-concentrate ration. Can. J. Anim. Sci. 48:269.

Forrest, R. J. 1975. Effects of castration, sire and hormone treatments on the quality of rib roasts from Holstein-Friesian males. Can. J. Anim. Sci. 55:287.

Forrest, R. J. 1978. Differences in carcass proportions and composition in control and hormone-treated Holstein-Friesian steers and bulls. Can. J. Anim. Sci. 58:333.

Fredeen, H. T., A. H. Martin, G. M. Weiss, S. B. Slen and L. J. Sumption. 1972. Feedlot and carcass performance of young bulls representing several breed and breed crosses. Can. J. Anim. Sci. 52:241.

Galbraith, H., D. G. Dempster and T. B. Miller. 1978. A note on the effect of castration on the growth performance and concentrations of some blood metabolites and hormones in British Friesian male cattle. Anim. Prod. 26:339.

Garrigus, R. R., T. G. Martin, M. Stob and D. R. Perks. 1969. Influence of creep feeding and post-weaning diethylstilbestrol implantation on post-weaning weight gain and carcass composition of beef bulls. J. Anim. Sci. 29:75.

Glimp, H. A., M. E. Dikeman, H. J. Tuma, K. E. Gregory and L. V. Cundiff. 1971. Effect of sex condition on growth and carcass traits of male Hereford and Angus cattle. J. Anim. Sci. 33:1242.

Gortsema, S. R., J. A. Jacobs, R. G. Sasser, T. L. Gregory and R. C. Bull. 1974. Effects of endogenous testosterone on production and carcass traits in beef cattle. J. Anim. Sci. 39:680.

Gray, D. G., J. A. Unruh, M. E. Dikeman and L. R. Corah. 1983. Effects of zeranol implantation periods on carcass characteristics of young bulls and steers. J. Anim. Sci. 57(Suppl. 1):218.

Gregory, K. E. 1982. Breeding and production of beef to optimize production efficiency, retail product percentage and palatability characteristics. J. Anim. Sci. 55:716.

Gregory, K. E. and J. J. Ford. 1983. Effects of late castration, zeranol and breed group on growth, feed efficiency and carcass characteristics of late maturing bovine males. J. Anim. Sci. 56:771.

Gregory, K. E., S. C. Seideman and J. J. Ford. 1983. Effects of late castration, zeranol and breed group on composition and palatability characteristics of longissimus muscle of bovine males. J. Anim. Sci. 56:781.

Hall, G. A. B. 1977. Zeranol, anabolico para ruminantes: Uma revisao. Rev. Soc. Bras. Zoot. 6:86.

Harte, F. J. 1969. Six years of bull beef production research in Ireland. In: D. N. Rhodes (Ed.) Meat Production from Entire Male Animals. pp 153-171. J. and A. Churchill Ltd., London.

Hawrysh, Z. J. and R. T. Berg. 1975. Eating quality of beef from young bulls as influenced by breed. Can. Inst. Food Sci. Technol. J. 8:149.

Hedrick, H. B. 1968. Bovine growth and composition. Missouri Agr. Exp. Sta. Bull. 928.

Hedrick, H. B. 1972. Beef cattle type and body composition for maximum efficiency. J. Anim. Sci. 34:870.

Hedrick, H. B., G. B. Thompson and G. F. Krause. 1969. Comparison of feedlot performance and carcass characteristics of half-sib bulls, steers and heifers. J. Anim. Sci. 29:687.

Heitzman, R. J. 1978a. Anabolic agents in beef production: Their action as growth promoters. In: H. DeBoer and J. Martin (Ed.) Patterns of Growth and Development in Cattle. pp 353-359. Martinus Nijhoff, Boston.

Heitzman, R. J. 1978b. The use of hormones to regulate the utilization of nutrients in farm animals: Current farm practices. Proc. Nutr. Soc. 37:289.

Hunsley, R. E., R. L. Vetter, E. A. Kline and W. Burroughs. 1967. Effects of age, sex and diethylstilbestrol on feedlot performance, carcass characteristics and muscle tenderness of male beef cattle. J. Anim. Sci. 26:1469 (Abstr.).

Hunsley, R. E., R. L. Vetter, E. A. Kline and W. Burroughs. 1971. Effects of age and sex on quality, tenderness and collagen content of bovine longissimus muscle. J. Anim. Sci. 33:933.

Jacobs, J. A., T. L. Gregory, R. G. Sasser, S. R. Gortsema, R. C. Bull and M. Hemstrom. 1975a. Feedlot and carcass characteristics of bulls vs steers for beef production. Idaho Agr. Exp. Sta. Bull. 556.

Jacobs, J. A., A. D. Howes, J. C. Miller, E. A. Sauter, T. L. Gregory, C. E. Hurst, M. R. Samson and A. A. Araji. 1975b. Profitability and consumer acceptability of beef from feedlot bulls versus steers. College of Agr., Univ. Idaho, Moscow.

Jacobs, J. A., C. E. Hurst, J. C. Miller, A. D. Howes, T. L. Gregory and T. P. Ringkob. 1977a. Bulls versus steers. I. Carcass composition, wholesale yields and retail values. J. Anim. Sci. 45:695.

Jacobs, J. A., J. C. Miller, E. A. Sauter, A. D. Howes, A. A. Araji, T. L. Gregory and C. E. Hurst. 1977b. Bulls versus steers. II. Palatability and retail acceptance. J. Anim. Sci. 45:699.

Jeremiah, L. E. 1978. A review of factors affecting meat quality. Agr. Canada Res. Branch Tech. Bull. 1.

Johnson, R. C., D. H. Gee, B. C. Paterson and L. B. Bruce. 1983. Effects of Synovex-S implants on carcass characteristics of intact and early feedlot castrated Angus bulls. J. Anim. Sci. 57(Suppl. 1):224.

Kahl, S., J. Bitman and T. S. Rumsey. 1978. Effect of Synovex-S on growth rate and plasma thyroid hormone concentrations in beef cattle. J. Anim. Sci. 46:232.

Klosterman, E. W., V. R. Cahill, L. E. Kunkle and A. L. Moxon. 1955. The subcutaneous implantation of stilbestrol in fattening bulls and steers. J. Anim. Sci. 14:1050.

Klosterman, E. W., L. E. Kunkle, P. Gerlaugh and V. R. Cahill. 1954. The effect of age of castration upon rate and economy of gain and carcass quality of beef calves. J. Anim. Sci. 13:817.

Koch, R. M., M. E. Dikeman, D. M. Allen, M. May, J. D. Crouse and D. R. Campion. 1976. Characterization of biological types of cattle III. Carcass composition, quality and palatability. J. Anim. Sci. 43:48.

Koch, R. M. M. E. Dikeman, R. J. Lipsey, D. M. Allen and J. D. Crouse. 1979. Characterization of biological types of cattle-cycle II: III. Carcass composition, quality and palatability. J. Anim. Sci. 49:448.

Koers, W. C., J. C. Parrott, III, R. H. Klett and L. B. Sherrod. 1974a. Implants for steers on pasture and in the feedlot. J. Anim. Sci. 39:243 (Abstr.).

Koers, W. C., J. C. Parrott, III, R. H. Klett and L. B. Sherrod. 1974b. Implant systems with growing-finishing steers. J. Anim. Sci. 39:244 (Abstr.).

Kogel, S. and H. Alps. 1978. Carcass composition of different breeds. In: H. DeBoer and J. Martin (Ed.) Patterns of Growth and Development in Cattle. pp 515-522. Martinus Nijhoff, Boston.

Koger, T., H. Elliot, F. G. Harbaugh and R. M. Durham. 1960. Sex effects on carcass and productive traits in fattening beef calves. J. Anim. Sci. 19:1238 (Abstr.).

Kunkle, L. E., E. W. Klosterman and V. R. Cahill. 1955. Carcass composition of steers and bulls with and without stilbestrol administration during the fattening period. J. Anim. Sci. 14:1231 (Abstr.).

Laflamme, L. F. and T. D. Burgess. 1973. Effect of castration, ration and hormone implants on the performance of finishing cattle. J. Anim. Sci. 36:762.

Landon, M. E., H. B. Hedrick and G. B. Thompson. 1978. Live animal performance and carcass characteristics of beef bullocks and steers. J. Anim. Sci. 47:151.

Levy, D., Z. Holzer and Y. Folman. 1976. Effects of plane of nutrition, diethylstilboestrol implantation and slaughter weight on the performance of Israeli-Friesian intact male cattle. Anim. Prod. 22:55.

Lewis, P. K., Jr., C. J. Brown and M. C. Heck. 1965. Effects of pre-slaughter treatment and castration on certain organoleptic and carcass characteristics of beef. Arkansas Agr. Exp. Sta. Bull. 697.

Lorenz, F. W. 1943. Fattening cockerels by stilbestrol administration. Poul. Sci. 22:190.

Lorenz, F. W. 1945. The influence of diethylstilbestrol on fat deposition and meat quality in chickens. Poul. Sci. 24:128.

Martin, T. G., J. L. Albright and M. Stob. 1965. Comparison of growth rate and carcass traits of bulls, stilbestrol-treated bulls, and steers of the Holstein-Friesian breed. J. Dairy Sci. 48:813 (Abstr.).

Martin, T. G. and M. Stob. 1978. Growth and carcass traits of Holstein steers, bulls and bulls implanted with diethyl-stilbestrol. J. Dairy Sci. 61:132.

Murphey, C. E., D. K. Hallett, W. E. Tyler and J. C. Pierce, Jr. 1960. Estimating yields of retail cuts from beef carcasses. J. Anim. Sci. 19:1240 (Abstr.).

Neumann, A. L. 1977. Beef Cattle (7th Ed.). pp 647-652. John Wiley and Sons, New York.

Nichols, J. R., J. H. Ziegler, J. M. White, E. M. Kesler and J. L. Watkins. 1964. Production and carcass characteristics of Holstein-Friesian bulls and steers slaughtered at 800 or 1000 pounds. J. Dairy Sci. 47:179.

NLS & MB. 1979. Beef steak color guide. National Live Stock and Meat Board, Chicago, IL.

Ntunde, B. N., W. R. Usborne and G. C. Ashton. 1977. Responses in meat characteristics of Holstein-Friesian males to castration and diet. Can. J. Anim. Sci. 57:449.

Nygaard, L. J., H. D. Radloff and M. L. Riley. 1971. Holstein bulls and steers for meat production. J. Anim. Sci. 33:221 (Abstr.).

Pasierbski, Z., S. Wawrzynczak, W. Mazurkiewicz, K. Pujszo and S. Leoniuk. 1978. Zastosowania preparatu "Ralgro" w opaisie mlodego bydla. Rocz. Nauk. Zootech. 12:113.

Paterson, B. C., D. H. Gee. R. C. Johnson and L. B. Bruce. 1983. The effects of growth promoting implants on carcass characteristics of Gelbvieh bulls. J. Anim. Sci. 57(Suppl. 1):230.

Perry, T. W., M. Stob, D. A. Huber and R. C. Peterson. 1970. Effect of subcutaneous implantation on resorcylic acid lactone on performance of growing and finishing beef cattle. J. Anim. Sci. 31:789.

Preston, R. L. 1975. Biological responses to estrogen additives in meat producing cattle and lambs. J. Anim. Sci. 41:1414.

Preston, R. L., E. W. Klosterman and V. R. Cahill. 1971. Hormone preparations for growing-finishing bulls: A 2-year summary. Ohio Agr. Res. Dev. Center Beef Cattle Res. Summary 52. pp 27-32.

Price, M. A. and T. Tennessen. 1981. Preslaughter management and dark-cutting in the carcasses of young bulls. Can. J. Anim. Sci. 61:205.

Price, M. A. and N. T. M. Yeates. 1969. Growth rates and carcass characteristics in steers and partial castrates. In: D. N. Rhodes (Ed.) Meat Production from Entire Male Animals. pp 69-77. J. and A. Churchill Ltd., London.

Ramsey, C. B., J. W. Cole, B. H. Meyer and R. S. Temple. 1963. Effects of type and breed of British, Zebu and dairy cattle on production, palatability and composition. II. Palatability differences and cooking losses as determined by laboratory and family panels. J. Anim. Sci. 22:1001.

Ray, D. E., W. H. Hale and J. A. Marchello. 1969. Influence of season, sex and hormonal growth stimulants on feedlot performance of beef cattle. J. Anim. Sci. 29:490.

Ray, E. E., A. Velasco, R. L. Shaw and W. D. Gorman. 1974. Growth and carcass traits of Mor-Lean and steer beef. J. Anim. Sci. 38:1328 (Abstr.).

Reagan, J. O., Z. L. Carpenter, G. C. Smith and G. T. King. 1971. Comparison of palatability traits of beef produced by young bulls and steers. J. Anim. Sci. 32:641.

Rhee, K. S., T. R. Dutson, G. C. Smith, R. L. Hostetler and R. Reiser. 1982. Cholesterol content of raw and cooked beef longissimus muscles with different degrees of marbling. J. Food Sci. 47:716.

Rhodes, D. N. 1969a. Meat Production from Entire Male Animals. J. and A. Churchill Ltd., London.

Rhodes, D. N. 1969b. The quality of meat from male and non-male animals. In: D. N. Rhodes (Ed.) Meat Production from Entire Male Animals. pp 189-196. J. and A. Churchill Ltd., London.

Robertson, I. S., J. L. Hubard Ocariz, J. C. Wilson and H. Paver. 1969. Gonadectomy in intensive beef production. In: D. N. Rhodes (Ed.) Meat Production from Entire Male Animals. pp 79-90. J. and A. Churchill Ltd., London.

Rumsey, T. S. 1978. Effects of dietary sulfur addition and Synovex-S ear implants on feedlot steers fed an all-concentrate finishing diet. J. Anim. Sci. 46:463.

Scott, B. M. 1978. The use of growth promoting implants in beef production. Great Britain A.D.A.S. Quarterly Rev. 31:185.

Seideman, S. C., H. R. Cross, R.R. Oltjen and B. D. Schanbacher. 1982. Utilization of the intact male for red meat production: A review. J. Anim. Sci. 55:826.

Sharp, G. D. and I. A. Dyer. 1970. Metabolic responses to zearalanol implants. J. Anim. Sci. 30:1040 (Abstr.).

Sharp, G. D. and I. A. Dyer. 1971. Effect of zearalanol on the performance and carcass composition of growing-finishing ruminants. J. Anim. Sci. 33:865.

Smith, G. C. 1982. Quality characteristics of beef from young intact males. Proc. U.S. Beef Symposium, Beef from Young, Intact Males. pp 16-23. Kansas State Univ., Manhattan.

Steel, R. G. D. and J. H. Torrie. 1980. Principles and Procedures of Statistics (2nd Ed.). McGraw-Hill Book Company, New York.

Stout, J. D. 1980. The effects of sex and hormonal implant on carcass characteristics and palatability. M.S. Thesis. South Dakota State University, Brookings.

Thiex, P. J. and L. B. Embry. 1972. Feedlot performance of bulls and the response to diethylstilbestrol or zeranol. South Dakota Agr. Exp. Sta. A.S. Series 72-22. pp 68-70.

Thomas, O. O. 1979. The relative value of growth promotives in beef cattle feeding. Great Plains Beef Cattle Handbook Bull. 1603.

Turton, J. D. 1969. The effect of castration on meat production from cattle, sheep and pig. In: D. N. Rhodes (Ed.) Meat Production from Entire Male Animals. pp 1-49. J. and A. Churchill Ltd., London.

USDA. 1975. Official United States standards for grades of carcass beef. USDA, Food Safety and Quality Service, Washington, DC.

Utley, P. R., G. L. Newton, R. J. Ritter, III and W. C. McCormick. 1976. Effects of feeding monensin in combination with zeranol and testosterone-estradiol implants for growing and finishing heifers. J. Anim. Sci. 42:754.

Vanderwert, W., L. L. Berger, P. J. Bechtel and F. K. McKeith. 1983. Effect of Zeranol implants on growth and carcass characteristics of bulls and steers of two breeds. J. Anim. Sci. 57(Suppl. 1):77.

Watson, M. J. 1969. The effects of castration on the growth and meat quality of grazing cattle. Australian J. Exp. Agr. Anim. Husb. 9:164.

Weninger, J. H. and D. Steinhauf. 1968. Meat quality in respect to carcass evaluation in cattle. World Rev. Anim. Prod. 4:87.

Wierbicki, E., L. E. Kunkle, V. R. Cahill and F. E. Deatherage. 1956. Post mortem changes in meat and their possible relation to tenderness together with some comparisons of meat from heifers, bulls, steers, and diethylstilbestrol treated bulls and steers. Food Technol. 10:80.

Williams, D. B., R. L. Vetter, W. Burroughs and D. G. Topel. 1975a. Effects of ration protein level and diethylstilbestrol implants on early-weaned beef bulls. J. Anim. Sci. 41:1525.

Williams, D. B., R. L. Vetter, W. Burroughs and D. G. Topel. 1975b. Dairy beef production as influenced by sex, protein level and diethylstilbestrol. J. Anim. Sci. 41:1532.

Wilson, L. L. and L. A. Burdette. 1973. Effects of various implants on beef gains. J. Anim. Sci. 37:372 (Abstr.).

Wilson, L. L., H. Varela-Alvarez, M. C. Rugh and M. L. Borger. 1972. Growth and carcass characters of rams, cryptorchids, wethers and ewes subcutaneously implanted with zeranol. J. Anim. Sci. 34:336.

Winer, L. K., P. J. David, C. M. Bailey, M. Read, T. P. Ringkob and M. Stevenson. 1981. Palatability characteristics of the longissimus muscle of young bulls representing divergent beef breeds and crosses. J. Anim. Sci. 53:387.

Wipf, V. K., J. W. Carpenter, H. L. Chapman, Jr., A. Z. Palmer and T. J. Cunha. 1964. Effects of slaughter age and diethylstilbestrol implants on feedlot performance and carcass characteristics of bulls and steers. J. Anim. Sci. 23:865 (Abstr.).

# APPENDIX

TABLE 1. ANALYSIS OF VARIANCE FOR CARCASS CUTABILITY TRAITS

| | | Mean squares | | | | |
|---|---|---|---|---|---|---|
| Source | df | Hot carcass wt | Longissimus muscle area | Fat thick-ness | Est. KPH fat | USDA yield grade |
| Treatment (T) | 3 | 1301.83 | 91.60 | .54** | .57 | 1.44** |
| Breed (B) | 1 | 44840.39** | 3403.75** | 26.63** | .24 | 39.58** |
| T x B | 3 | 956.50 | 49.19 | .12 | .65 | .27 |
| Residual | 187 | 801.51 | 76.06 | .08 | .35 | .31 |
| Total | 194 | | | | | |

** P< .01.

TABLE 2. ANALYSIS OF VARIANCE FOR MATURITY SCORE, MARBLING SCORE AND USDA QUALITY GRADE

| | | Mean squares | | |
|---|---|---|---|---|
| Source | df | Maturity score | Marbling score | USDA quality grade |
| Treatment (T) | 3 | .06 | 4.38 | 2.44 |
| Breed (B) | 1 | .59* | 444.24** | 278.23** |
| T x B | 3 | .05 | 2.21 | 2.00 |
| Residual | 187 | .10 | 3.03 | 1.68 |
| Total | 194 | | | |

* P< .05.
** P< .01.

TABLE 3. ANALYSIS OF VARIANCE FOR COOKING CHARACTERISTICS AND SENSORY EVALUATION

| Source | df | Mean squares | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Cooking time | Cooking loss | Degree of doneness score | Juiciness score | Tenderness score | Amount of connective tissue score | Flavor desirability score | Overall desirability score |
| Treatment (T) | 3 | 18.75 | 10.95 | .35 | .29 | .91 | .54 | .10 | .08 |
| Breed (B) | 1 | .01 | .05 | 1.51 | .11 | 5.67** | 4.28** | .41 | 2.52* |
| T x B | 3 | 85.71 | 13.19 | .41 | .36 | 1.50 | .51 | .41 | .17 |
| Residual | 72 | 32.08 | 19.07 | .40 | .38 | .61 | .48 | .21 | .41 |
| Total | 79 | | | | | | | | |

* P<.05.
** P<.01.

TABLE 4. ANALYSIS OF VARIANCE FOR WARNER-BRATZLER SHEAR EVALUATION

| Source | df | Mean squares: Cooking time | Mean squares: Warner-Bratzler shear force |
|---|---|---|---|
| Treatment (T) | 3 | 63.28 | 1.29 |
| Breed (B) | 1 | 211.25** | 18.07** |
| T x B | 3 | 21.95 | 5.11 |
| Residual | 72 | 29.07 | 2.01 |
| Total | 79 | | |

** P<.01.

TABLE 5. ANALYSIS OF VARIANCE FOR CHEMICAL COMPOSITION OF LONGISSIMUS MUSCLE AND MARBLING SCORE

| Source | df | Mean squares: Fat | Mean squares: Water | Mean squares: Protein | Mean squares: Marbling score |
|---|---|---|---|---|---|
| Treatment (T) | 3 | 4.15* | 3.44** | .43 | 9.68* |
| Breed (B) | 1 | 24.18** | 8.44** | 4.05** | 186.05** |
| T x B | 3 | 2.63 | 2.87** | .28 | 4.68 |
| Residual | 72 | 1.08 | .65 | .34 | 3.05 |
| Total | 79 | | | | |

* P<.05.
** P<.01.

TABLE 6. POOLED WITHIN SUBCLASS CORRELATION COEFFICIENTS AMONG CARCASS TRAITS[a]

| Item | Hot carcass weight | Longissimus muscle area | Fat thickness | Est. KPH fat | USDA yield grade | Maturity score | Marbling score |
|---|---|---|---|---|---|---|---|
| Longissimus muscle area | .60** | | | | | | |
| Fat thickness | -.23** | -.39** | | | | | |
| Est. KPH fat | .01 | -.08 | .19** | | | | |
| USDA yield grade | -.16* | -.70** | .85** | .34** | | | |
| Maturity score | -.31** | -.14 | .09 | -.05 | .02 | | |
| Marbling score | -.32** | -.47** | .72** | .29** | .70** | .11 | |
| USDA quality grade | -.32** | -.45** | .74** | .27** | .69** | .11 | .97** |

[a] N = 195.
* P< .05.
** P< .01.

TABLE 7. POOLED WITHIN SUBCLASS CORRELATION COEFFICIENTS AMONG CARCASS AND MEAT TRAITS[a]

| | Taste panel | | | | | | | | Warner-Bratzler | | Longissimus muscle composition | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Carcass trait | Cooking time | Cooking loss | Degree of doneness score | Juiciness score | Tenderness score | Amount of connective tissue score | Flavor desirability score | Overall desirability score | Cooking time | Shear force | Fat | Water | Protein |
| Hot carcass weight | .23* | .24* | .02 | -.23* | -.24* | -.25* | -.17 | -.22 | .20 | .19 | -.22* | .02 | .41** |
| Longissimus muscle area | .20 | .14 | .07 | -.11 | -.16 | -.20 | -.19 | -.21 | .40** | .07 | -.39** | .29** | .33** |
| Fat thickness | -.03 | .06 | .12 | .02 | .16 | .13 | .06 | .18 | -.17 | -.14 | .63** | -.66** | -.24* |
| Est. KPH fat | -.05 | -.01 | -.13 | -.10 | -.02 | -.10 | -.05 | -.06 | -.14 | -.01 | .34** | -.42** | -.03 |
| USDA yield grade | -.07 | .03 | .01 | -.02 | .11 | .10 | .09 | .16 | -.33** | -.06 | .63** | -.66** | -.23* |
| Maturity score | -.17 | -.18 | .05 | .23* | .32** | .28* | .13 | .27* | -.04 | -.36** | .07 | .02 | -.18 |
| Marbling score | -.11 | .05 | .14 | -.02 | .19 | .15 | .08 | .18 | -.25* | -.21 | .70** | -.69** | -.32** |
| USDA quality grade | -.07 | .07 | .10 | .06 | .18 | .13 | .11 | .20 | -.23* | -.17 | .69** | -.68** | -.32** |

[a] N = 80.
* P<.05.
** P<.01.

TABLE 8. POOLED WITHIN SUBCLASS CORRELATION COEFFICIENTS AMONG MEAT TRAITS[a]

| Item | Cooking time | Cooking loss | Degree of doneness score | Juiciness score | Tenderness score | Amount of connective tissue score | Flavor desirability score | Overall desirability score | Warner-Bratzler Cooking time | Warner-Bratzler Shear force | Longissimus muscle Fat | Longissimus muscle Water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Taste panel | | | | | | | | | | | |
| Cooking loss | .74** | | | | | | | | | | | |
| Degree of doneness score | .15 | .34** | | | | | | | | | | |
| Juiciness score | -.10 | -.37** | -.26* | | | | | | | | | |
| Tenderness score | -.10 | -.19 | .13 | .43** | | | | | | | | |
| Amount of connective tissue score | -.10 | -.21 | .11 | .40** | .90** | | | | | | | |
| Flavor desirability score | .15 | .03 | -.05 | .54** | .40** | .48** | | | | | | |
| Overall desirability score | -.05 | -.22 | .01 | .67** | .85** | .85** | .74** | | | | | |
| Warner-Bratzler | | | | | | | | | | | | |
| Cooking time | -.02 | -.02 | -.17 | .09 | -.20 | -.25* | -.17 | -.20 | | | | |
| Shear force | .10 | .11 | -.17 | -.05 | -.53** | -.53** | -.01 | -.41** | .19 | | | |
| Longissimus muscle | | | | | | | | | | | | |
| Fat | -.02 | .01 | -.09 | .04 | .26* | .20 | -.03 | .19 | -.22* | -.23* | | |
| Water | -.01 | -.09 | .02 | .01 | -.13 | -.05 | .06 | -.10 | .15 | .18 | -.87** | |
| Protein | .05 | .12 | .15 | -.08 | -.33** | -.33** | -.04 | -.22 | .21 | .17 | -.65** | .19 |

[a] N = 80.
* P<.05.
** P<.01.