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ACCELERATED BEEF PRODUCTION: EFFICIENCY, COMPOSITION AND ACCEPTABILITY OF BEEF FROM FIVE BIOLOGICAL TYPES SLAUGHTERED AT THREE WEIGHT ENDPOINTS

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David Glenn Lust

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ABSTRACT

ACCELERATED BEEF PRODUCTION: EFFICIENCY, COMPOSITION AND ACCEPTABILITY OF BEEF FROM FIVE BIOLOGICAL TYPES SLAUGHTERED AT THREE WEIGHT ENDPOINTS

By

David Glenn Lust

Two hundred four steer calves from five breed groups (BG) were allocated by weaning weight into three slaughter weight endpoint groups (SG) in a study to evaluate feedlot performance, carcass composition, palatability and cholesterol characteristics of cattle in an accelerated production system. Breed groups consisted of unselected Herefords, Herefords selected for growth, Hereford x Angus x Shorthorn, Simmental x Gelbvieh x Holstein, and Angus. All cattle were fed an 80% concentrate diet from weaning until slaughter. USDA choice carcasses were purchased to serve as controls. Significant BG x SG interactions existed for average daily gain (ADG), carcass weight, quality grade, % carcass fat, % carcass protein, and weaning serum cholesterol ($p<.05$). There were no significant differences ($p>.10$) among BG and controls for any palatability measures. Longissimus dorsi muscle cholesterol was not different among BG, but was significantly higher ($p<.05$) for SG 3. Muscle cholesterol was not correlated to serum cholesterol or carcass fatness measures. These data suggest that calves fed a high energy diet from weaning until 11 to 15 mo. of age will produce beef of acceptable palatability.

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Introduction

Beef consumed in the United States has traditionally been produced under a two-phase system. Calves are normally weaned at 180-300 days of age and grown or "backgrounded" on a high roughage diet for a period of several months to a year. The second phase involves feeding a high concentrate diet for four to six months. The major advantages of such a system are that otherwise underutilized forage resources can be used, and rapid compensatory gains during the finishing phase create profit potential for feeders. Under such a system, however, cattle are 17-30 months of age and may have changed ownership several times before reaching slaughter. Carcasses produced normally have an average USDA yield grade (YG) of 3.5 and a USDA quality grade (QG) of low choice. Beef production under such a system has continued despite the high maintenance, interest, transportation, commission, and health costs associated with the long production cycle.

In recent years, the American public has become increasingly health and diet conscious, and beef demand has declined in part due to the public perception that beef may pose a health threat due to its fat and cholesterol content. In addition, inconsistent quality has also lowered the demand for beef. The beef packing and retail industry has responded by demanding leaner and more consistent beef. Unfortunately, this occurs at a time when the beef cattle population is more diverse than ever, and the demand for a Choice quality grade and high dressing percent continues to be antagonistic to lean beef production.

The goal of animal scientists and beef producers should be to find methods to efficiently produce lean, palatable beef. Potential for improved efficiency, reduced costs, and a leaner and more uniform product may exist in a system of accelerated beef production. Such a system would utilize biological types of high growth potential, which could be placed on a high concentrate diet immediately after weaning and slaughtered at one year of age or less. With proper implementation, this system may provide one means of achieving the previously stated goal.

While it is generally accepted that animals of high growth potential fed a high concentrate diet will grow at an accelerated rate, the total effects of an accelerated feeding system versus a conventional one have not been thoroughly researched. In addition, relatively little effort has been made to identify the optimum biological types for use in an accelerated system. Finally, while the youth of cattle from such a system would suggest acceptable tenderness, palatability characteristics of such beef have not been quantified. Therefore, if an accelerated system is to improve the efficiency and quality of beef production, these questions must be further researched.

Review of Literature

Effects of Feeding And Management Programs

A positive relationship between diet energy density and average daily gain (ADG) is well established, (Harte, 1968a, Bowling et al., 1978; Dinius and Cross, 1978). Higher energy diets support increased ADG due to increased metabolizable energy (ME) intake. Feeding programs supporting high ME intake and ADG also commonly result in increased feed efficiency (gain:feed) due to the dilution of maintenance cost (Dikeman, 1973; Rompala, 1984). At low energy densities, intake of ME is often limited by the animal's physical ability to consume feed (Bennett, 1986). Rompala et al. (1984) reported that faster gaining steers had improved feed efficiency.

Compensatory Gain

U.S. beef cattle are rarely fed to slaughter on a high forage (low energy) diet only. Normally the diet is changed from predominately forage to high concentrate prior to slaughter. Numerous investigators have demonstrated a compensatory increase in gain when cattle are moved from a relatively low plane of nutrition to a high energy diet. Osborne and Mendel (1915) were among the first to find that gain continued at an accelerated rate upon realimenation after long periods of nutrient restriction, a finding confirmed by most researchers working in this area since that time. In addition to increased rate of gain, several researchers have shown more efficient weight gain during the recovery period (Winchester and Howe, 1955; Meyer and Clawson, 1964; Meyer et al., 1965; Harte, 1968a; Fox et al., 1972). Conflicting reports remain, however, in regard to the efficiency of continuous vs restricted-plus-compensatory gain over the entire growing period. Results vary in part due to experimental conditions, length and severity of nutrient restriction, length of the recovery period, and nutritional plane during the recovery period. The physiological mechanisms of compensatory gain have yet to be fully explained. Increased protein and less fat deposition (Sheehy and Senior, 1942), increased feed intake (Osborne and Mendel, 1916; Quinby, 1948; Taylor, 1959; Fox, 1972), and increased energy and protein utilization (Meyer and Clawson, 1964; Meyer et al., 1965; Fox, et al., 1972) during the recovery period appear to contribute to the compensatory gain exhibited.

Feedlot Performance In Accelerated And Conventional Systems

Regardless of the mechanisms involved, the repeatability of compensatory gain and the need to utilize forage resources have been sufficient to promote adoption of two-phase feeding systems. Thus, the comparison of cattle performance on high concentrate only (accelerated) or forage followed by concentrate (conventional) feeding systems is of primary interest.

Lancaster et al. (1973), placed weanling Angus steers on treatments of concentrate only (194d) or grazing (76d) plus concentrate (118d) to evaluate performance and carcass traits. Steers in the accelerated group had greater feed intake and superior feed conversion (F:G) over the total feeding period. The steers in the conventional group gained faster during the 118d finishing period, but ADG and final weights were not different between the two groups over the entire feeding period.

Ridenour et al., (1982) utilized 365 crossbred weanling steers to evaluate five nutrition and management programs, consisting of a high concentrate diet for 229d, or four forage then concentrate combinations. Steers on the high concentrate only treatment gained faster (1.22 vs 1.03 kg/d) and consumed less feed/per unit of gain (7.31 vs 8.82) than those on the two-phase treatments. Windels et al., (1982) allotted 120 Charolais x British crossbred steer calves (265 kg) to continuous high grain or two-phase corn silage then grain dietary treatments. Steers on the continuous high grain program gained faster in all stages of the trial. Dry matter consumption was higher for calves on the continuous high grain treatment during the 92d growing period, but was not significantly different for the entire period. Therefore, steers fed continuous high grain diets required less DM/kg gain

(5.77 vs 6.11) than calves fed in the two-phase system.

Similar results were found by Dikeman et al., (1985a,b) in two trials evaluating accelerated and two-phase production systems. Cattle on the accelerated treatments gained faster over the entire period than those on the two-phase treatments. ADG during the finishing periods favored cattle on the conventional programs. All cattle on the accelerated systems had lower ME:gain ratios then those on the two-phase treatment, due to a dilution of ME used for maintenance.

Composition of Gain

While the increase in rate and efficiency of gain associated with accelerated systems and with the finishing phase of deferred feeding systems seems attractive economically, composition of this gain is a possible point of concern. Moulton (1922, 1923) proposed that body composition on a fat-free basis was essentially constant, and concluded that the main effect of increased plane of nutrition and age was an increase in fat. Moulton's classic work has been supported by Geunther et al. (1965), and Jesse et al. (1976) who found that fat as a percentage of empty body gain and carcass gain increased as slaughter weight increased. Composition of empty body and carcass gain was not affected by diet.

More recently, Byers and Rompala (1979b) predicted rates of protein deposition using regression equations based on empty body weight and rate of gain. Rates of protein deposition increased at a decreasing rate as rate of daily gain increased. The authors concluded that rate of protein gain would be near (> 90%) maximum at 1.0 kg of daily gain, and that daily body weight gain greater than that would yield little increase in protein deposition. Fat deposition, on the other hand, increased at increasing rates as rate of gain and empty body weight increased.

In a review of seven trials, Bennett (1986) found that increased diet energy density resulted in faster growth rates in all trials, but found little difference in non-fat carcass weight gains, leading to the conclusion that faster weight gains were due to disproportionately large increases in rate of fat deposition. The findings are particularly relevant when considering that fat gain is more energetically expensive than protein gain on a tissue weight basis (Thorbek, 1977), though not on a caloric basis (Bergen, 1974).

The concept of "backgrounding" cattle on a relatively low level of nutrition in order to allow increases in skeletal and muscle growth without large increases in fat has remained a debated issue in the scientific community, despite wide acceptance by the beef industry. Indeed, some scientists have suggested that composition of growth cannot be controlled or manipulated with dietary programs (Reid et al., 1968a,b; Topel, 1973; Bowling, 1979). Others (Callow, 1961; Jesse et al., 1976; Arthaud et al., 1977; Trenkle et al., 1978) have found nutritional regimes to have little effect on carcass composition as long as cattle are slaughtered at the same live weight or endpoint. Winchester and co-workers (1955, 1957a,b) found that twin calves subjected to a six month growth retardation period and then refed had similar F:G and carcass composition when slaughtered at the same live weight. In agreement is the more recent work of Ridenour et al. (1982), who reported no differences in slaughter or carcass weight, fat thickness, conformation, YG, or 9-10-11 rib composition of steers allotted to high concentrates only, or to wheat pasture followed by concentrate nutritional programs.

Dikeman et al. (1985), compared carcass characteristics and composition of steers fed on either an accelerated (concentrate only) or a conventional (two-phase) nutritional program. Cattle on the accelerated and two-phase systems were slaughtered when they were estimated to have 4.5% intramuscular lipid and at typical industry slaughter weights, respectively. There were no differences in percentages of carcass soft-tissue lipid or water between the two production systems. This point must be interpreted carefully however, as cattle on the accelerated program had less fat thickness, smaller LD muscle areas, and lower numerical YG, marbling scores and QG than cattle from the two-phase system. These differences likely reflect the lighter slaughter weights (92.3 kg less) of the cattle on the accelerated system. The authors predicted that the accelerated cattle would have been fatter than those on the conventional system if they had been slaughtered at the same heavier weight.

Numerous researchers, however, have reported substantial differences in composition of gain and carcass as the result of nutritional programs. Utley et al. (1975), Prior et al. (1977) and Young and Kauffman (1978) found that low-energy density diets produced carcasses with lower percentages of fat than those from cattle on a high energy density diet at the same slaughter weights. McMeekan, (1940b) used four combinations of high and low energy levels to determine the effect of two-phase nutritional systems on pigs. Pigs switched from the low to high energy level had 6% more carcass fat at equal weights (90 kg) than those on the high energy only program. In addition, the fat:muscle ratio of pigs on the low-then-high system was dramatically higher at 90 kg than for pigs on the other treatments.

This compensatory fattening effect produced by two-phase systems was also noted by Dikeman et al. (1985) who found steers grown on a conventional system to exceed those on accelerated systems in several measures of fatness. Length of time on the accelerated system seems an important variable however, as steers slaughtered at similar weights as those on the conventional system were similar in composition.

The concept of manipulating growth composition with nutritional levels and programs, and the widespread use of two-phase feeding programs based on this concept remain controversial. The nature of growth is complex, and conflicting conclusions have been reported largely due to the number of factors involved. Level of nutrition, length of feeding periods, growth rates, age, slaughter endpoint, and breed or type differences make accurate comparisons between trials very difficult. Breed and age differences will be discussed in later sections.

Palatability

Kurtz (1959) defined palatability as "the complex of sensations resulting from the senses of odor, taste, and feel". If that definition is expanded to include the sense of sight, it is easy to see the potential for difference of opinion regarding the palatability of any particular item. Since palatability is most often based upon the psychological and physical perceptions unique to an individual, objective quantification of palatability becomes exceedingly difficult. The determination of palatability in meat is most often accomplished through the use of taste panels. A consumer panel is most useful for determining broad acceptability of the product, while a trained or "laboratory" panel is expected to identify the major components contributing to beef palatability, namely, tenderness, juiciness and flavor. More objective measures also exist for tenderness and juiciness. An added problem is that cooking often alters palatability substantially, even if the aforementioned factors are previously quantified or controlled.

Tenderness has been identified as the variable most highly related to beef acceptability (Campion, 1975), and has received more study than any other palatability component. Tenderness may be determined objectively using any of several mechanical instruments, although these measurements quite often do not reflect human perceptions of tenderness.

Several characteristics of meat contribute to tenderness. The amount of connective tissue present in meat is highly related to tenderness (Ramsbottom and Strandine, 1948). Amounts of connective tissue may be diluted by rapidly increasing muscle fiber size in young, growing animals.

Muscle fiber characteristics also contribute to meat tenderness. The post-rigor contraction state of muscle fibers may be affected by tension on the muscle during the onset of rigor, and by prerigor temperature

(Locker and Hagyard, 1963). Greater sarcomere length is associated with increased tenderness (Howard and Judge, 1968; Marsh, 1972). Tenderness may also be affected by the structural integrity of muscle fibers, which is influenced by the action of cathepsins, calcium dependent proteases, and other proteolytic enzymes.

Intramuscular lipid content may play a small role in tenderness of meat. The fat may act as a barrier to water loss, contributing to the ease with which muscle fibers are ruptured (Sanderson and Vail, 1948). Finally, the lubricating and flavor characteristics of intramuscular fat may contribute to the perception of tenderness.

The "juice" or liquid content of meat is composed of water and melted intramuscular lipid. Juiciness is primarily affected by the water retention properties of the meat. Intramuscular and subcutaneous fat may contribute to juiciness by minimizing or decreasing water loss, and by stimulating salivation, thereby adding to perceived juiciness. Flavor is perhaps the least definable contributor to palatability of meat, for the simple reason that desirable flavor to one person may not be desirable to another. The determination of flavor is the result of the combination of olfactory and gustatory sensations unique to any one person. Components contributing to flavor are difficult to identify completely and unequivocally, although fat and lipid characteristics likely have a substantial influence (Hornstein et al., 1960). Breakdown products of ATP may also contribute to flavor, and would account for the stronger flavors often associated with frequently used muscle groups having large energy stores (Jones, 1969). Finally, length and conditions of storage may greatly influence chemical and microbiological action, eliciting marked changes in flavor.

Reliable predictors of palatability which may quickly and easily be determined have largely eluded researchers. The USDA quality grade (QG) has survived as the beef industry's most common indicator of beef palatability. Since QG is most affected by marbling score, it is logical to address that measure specifically. Marbling, by a strict definition, is intramuscular fat visible to the human eye in the cut surface of the longissimus dorsi (LD) muscle. For this review, however, that definition shall be broadened to include all intramuscular fat in the LD muscle. The value of marbling as a predictor of eating quality has been seriously questioned. Marbling may have little or no influence on tenderness (Palmer, 1958; Alsmeyer, 1959; Briedenstein, 1968) or flavor (Tuma, 1962; Romans, 1965; Walter, 1965; Parrish, 1973). In a review of literature, Blumer (1963) cites numerous researchers who suggest that QG does not affect the eating quality of beef. He concluded that approximately 5% of variation in taste panel tenderness could be attributed to marbling. More recently, Campion et al. (1975) utilized a large number of steer carcasses from various breeds and found tenderness to be the factor most highly related to acceptability. Marbling was lowly correlated with tenderness, and accounted for less than 10% of total taste panel variation, leading the authors to conclude that QG and marbling were poor predictors of palatability. These findings are in agreement with the work of Jost et al. (1983) who found that marbling accounted for only .4% of panel tenderness variation, and did not significantly contribute to variation in flavor, juiciness, or Warner-Bratzler shear values.

Perhaps the most recent and definitive study of this topic is the review of Parrish (1981), who concluded that correlations between marbling and palatability were most often positive and significant, but very low in magnitude. In addition, he found marbling to be more strongly related to juiciness than to tenderness, and the relationship to flavor quite variable.

Effect of Diet on Palatability

Beef palatability has been shown to improve as diet energy density is increased (Smith, 1977; Bowling, 1978; Schroeder, 1980; Aberle, 1981; Melton, 1982). These results should be interpreted with care, however, since the palatability differences in many such trials may be due to differences in carcass composition, rather than the dietary treatments per se. Extremely lean carcasses typical of forage fed beef may be susceptible to cold shortening and increased toughness. Several researchers have suggested a minimum of 6.4-8.0 mm of external fat necessary to prevent cold toughening (Dikeman, 1982; Dolezal et al., 1982). Dinius and Cross (1978), Bidner (1981), and Miller (1983) found no difference in tenderness due to diet among carcasses of similar composition. Rapid growth may be related to a decrease in collagen insolubility and crosslinking (Aberle, 1981; Hall and Hunt, 1982) providing a possible explanation for advantages in tenderness noted in cattle fed high energy diets.

Because cattle on accelerated feeding systems may be leaner and younger than cattle fed in a deferred system, a substantial number may fail to reach the choice QG. Thus, questions concerning the palatability of beef fed on accelerated systems have been raised. Several researchers have suggested that cattle fed a high concentrate diet some relatively short period of time prior to slaughter will reach acceptable levels of palatability. Zinn (1970a,b), and Dolezal (1982a) found the greatest improvements in palatability to occur in the first 50-100 days on a finishing diet. Smith (1977), and Dinius and Cross (1978) compared palatability traits of steers fed on concentrate only or deferred systems, and found no differences in palatability traits after 49 days on the concentrate diet. Bidner (1981) concluded that British crossbred steers of similar composition with minimums of 8mm subcutaneous fat and QG of Select were acceptable in palatability whether fed on a deferred or accelerated system. Aberle et al. (1981), noted no differences in palatability traits of steers fed for varying time periods on an accelerated or either of two deferred feeding programs. The authors postulated that growth rate was more important to palatability then days on feed, since the increased solubility of collagen and quantity of proteolytic enzymes associated with rapid protein synthesis and degradation contributed to meat tenderness.

Perhaps the most definitive work evaluating palatability attributes of cattle from accelerated and deferred systems is that of Dikeman and co-workers (1985 a,b). The authors utilized steers of two breed types to evaluate production and carcass processing systems. The accelerated system resulted in more desirable LD and semimembranosus (SM) tenderness scores, and equal LD flavor and juiciness scores as compared to the conventional system. Samples from the accelerated group yielded equal juiciness and superior flavor scores. In a subsequent trial, the experimenters used high percentage Simmental steers to compare accelerated systems of three durations to a conventional system, with similar results. In fact, the pooled accelerated system scores for SM were superior to those from the conventional in all measures of palatability except flavor, for which there were no differences. There were no differences in tenderness, flavor, or Warner-Bratzler shear force (WBS) values among LD samples from accelerated or conventional systems, although samples from two of the accelerated programs were less juicy than those from the conventional. These findings would suggest that cattle from accelerated feeding systems are equal to or superior in palatability to those from conventional systems, despite their lighter carcass weights and lower marbling scores and USDA quality grades.

The diet energy density prior to the finishing phase of deferred systems may also influence palatability. Miller et al. (1986) evaluated the effects of two prefinishing diets and found samples from steers on the higher energy diet to have superior marbling and tenderness scores, although there were no differences in WBS, juiciness, or flavor due to prefinishing regimen. These investigators also found no improvement in palatability traits after 56 days on a finishing diet when steers were slaughtered at a common age.

Cholesterol

Public perception of dietary cholesterol as a health hazard has increased in recent years, despite continued debate over this issue in the scientific community. Thus, some efforts to identify and/or manipulate cholesterol in beef have resulted. Feeley (1972), after a review of literature, concluded that selecting beef with lower levels of marbling or removing subcutaneous fat would do little to alter cholesterol content of beef. This may not be surprising if one considers the work of Reiser et al. (1975) who concluded that on a fresh weight basis fat contained less cholesterol than lean, a finding confirmed by Rhee et al. (1982) with both raw and cooked beef samples.

Efforts to influence muscle tissue cholesterol with dietary energy levels (Eichhorn et al., 1986), or fatty acid compositions (Bohac and Rhee, 1987) have produced no differences in muscle tissue cholesterol in beef cows, steers, or pigs. Stromer et al. (1966) reported that cholesterol content of subcutaneous beef fat increased with carcass maturity, but found no difference in LD muscle cholesterol among samples with different marbling scores. The extraction procedure used, however, may have been insufficient to equally remove cholesterol from both fat and muscle. These results however, have been supported by more recent workers (Rhee et al., 1982; Thompson et al., 1988) who discovered no differences in cholesterol content among raw or cooked steaks containing eight levels of marbling. Wheeler et al. (1987) found no difference in tissue cholesterol content due to breed type, sex, days on feed or marbling score, although serum cholesterol increased with fatness. However, no correlation between blood cholesterol (Wheeler, 1987; Rouse and Beitz, 1988) or subcutaneous rib fat (Rouse and Beitz 1986, 1988) and ribeye muscle cholesterol has been demonstrated.

Differences Among Breeds And Biological Types

Identification of optimum breed or biological types for specific nutritional or management systems has been the focus of numerous producers and researchers. The advantages in rate of gain and feed efficiency common to large mature size breeds or types of steers have been well demonstrated (Koch et al., 1976; Prior et al., 1977; Ferrell and Crouse, 1978; Crouse et al., 1985). Byers and Rompala (1979), found faster growing Charolais steers to gain more efficiently than Angus steers on a high energy diet due to greater rates of fat deposition. On this basis, they suggested that larger sized, faster gaining cattle would be well suited to accelerated feeding systems, since their rapid fat gain on high energy diets would allow them to reach desirable fatness endpoints at much lighter and more acceptable weights then if fed on a deferred system. By similar reasoning, the authors concluded that smaller, slower growing steers would be more efficiently utilized in a deferred system, where they could reach acceptable slaughter weights without becoming excessively fat. These observations are supported by the work of Schmidt et al. (1987), who found Charolais sired steers to be heavier and older than Polled Hereford sired steers at similar compositional endpoints when on a conventional system.

The validity of this concept was tested by Schalles et al., (1983) in a comparison of Simmental and Polled Hereford steers managed on accelerated or conventional systems. Simmental cattle on the accelerated program reached slaughter fatness at lighter weights and younger ages than when fed under deferred management, resulting in the most desirable YG and the least Mcal energy/kg retail cuts of any breed x system combination. Polled Hereford steers were more efficient than Simmental when on the conventional system, however, and reached market fatness at much lighter and more desirable slaughter weights. Efficiency from birth to slaughter was 4% greater for Simmental cattle on the accelerated system than for Polled Herefords under conventional management, while Polled Herefords were more efficient than Simmental on the deferred system. Polled Herefords on the accelerated treatment were the least efficient of any breed x management system combination.

Dikeman et al. (1985) utilized Angus x Hereford and Simmental x Chianina steers to evaluate accelerated and conventional systems. The large type steers tended to gain faster on both systems, and both cattle types on the accelerated system required less ME/gain than cattle on the conventional system. Efficiency of gain under accelerated management was greater for large type cattle, while there was no difference in ME/gain between breeds on the deferred feeding system.

Carcass Characteristics

Reported effects of breed or type differences on carcass characteristics may be quite variable, as many are confounded with various slaughter endpoints. In a summary of post-weaning management systems, Fox (1979) showed an increase in carcass weight as mature size increased in cattle slaughtered at similar QG. Dolezal et al. (1985) found frame score to be positively related to carcass weight and REA, and negatively related to several measures of fatness. These relationships have been substantiated by Crouse et al. (1985), who showed Simmental cattle to be heavier than Angus at similar levels of fatness, and by Newland et al., (1974), who found Charolais sired steers to be heavier, more muscular, and leaner than Herefords, whether on an accelerated or conventional system.

The data of Schalles et al. (1983) indicate that large framed, fast growing steers in an accelerated program produce superior carcasses more efficiently than smaller sized cattle. Simmental steers on the concentrate only feeding system produced heavier carcasses with less fat, larger REA, more desirable YG and more pounds of retail cuts than Polled Hereford steers on either accelerated or two-phase management. By design, there were no differences in QG between the two breeds. Similar findings were reported by Dikeman et al. (1985a), who found larger, faster gaining Simmental x Chianina steers to yield heavier, leaner, and more muscular carcasses than Angus-Hereford steers, although the smaller steers had higher QG.

Palatability

Smith et al. (1977a) found no significant differences in palatability due to breed type (Continental vs British) at constant fatness or age endpoints, although large steers scored lower than small in several palatability traits when compared at constant weights. Few differences in palatability traits can be detected if cattle are compared at similar ages and compositional endpoints (Koch et al., 1979; Aberle et al., 1981; Crouse et al., 1985). Dolezal et al. (1985), however, found that large framed steers had lower scores in juiciness and overall satisfaction than small frame steers.

No differences in LD palatability between Angus x Hereford and Simmental x Chianina steers on conventional or accelerated programs were detected by Dikeman et al. (1985a). For SM steaks, the workers found no taste panel differences, although, WBS values were higher for Simmental x Chianina cattle.

Cholesterol

Possible variation in cholesterol concentration in beef due to breed or type difference has remained largely undetermined. Few researchers have attempted to quantify cholesterol differnces among breed types directly, although other traits related to cholesterol concentration may be commonly associated with certain breeds, providing an indirect indication of possible variation. However, differences in cholesterol content due to breed have been difficult to demonstrate. Eichhorn et al. (1986) utilized mature cows representing 15 breeds or crosses and found no variation in cholesterol content of LD muscle due to breed or diet, and concluded that changing the cholesterol content of beef would be difficult.

Similar conclusions were reported by Wheeler et al. (1987) in a study comparing two extremely diverse breed groups. No differences in cooked or uncooked LD tissue cholesterol due to any main effect were noted. Leaner Chianina cattle in this study possessed significantly lower serum cholesterol concentration than British crossbreds. However, this is most likely a reflection of the relative composition of the breed groups, as serum cholesterol was positively correlated with several measures of fatness. These findings are in agreement with those of Koch et al. (1987) who have shown no differences in lean tissue cholesterol among Brahman or Hereford cattle, or Bison.

Rouse and Beitz (1988) reported no difference in cholesterol concentrations in muscle, liver, or serum among cattle representing three frame sizes.

Influence Of Age

Age of U.S. slaughter cattle is widely variable, and often unknown. The precise effects of age on various traits of interest are relatively poorly documented, since age is often uncontrolled or confounded with other factors. Cattle are normally slaughtered at 17-24 months of age, although wider ranges may exist as the result of deferred feeding systems, physiological maturity patterns, and market conditions.

Dikeman et al. (1985b) slaughtered Simmental steers at four ages ranging from 12 to 17.5 months and discovered no differences in ADG or F:G due to age. In contrast, Lunt et al. (1987) found that heifers fed as yearlings tended to gain faster and were significantly more efficient than heifers fed as calves.

Ramsey et al. (1967), and Bowling et al., (1978) showed an increase in percent carcass fat as age increased. The largest changes however, occurred from 3 to 24 months, with fat increasing at decreasing rates after that point.

Several researchers have suggested that feeding cattle on an accelerated system and slaughtering at young ages (9-13 mo.) would produce leaner beef more efficiently. Texas workers (Rouquette and Carpenter, 1981; Rouquette et al., 1983) slaughtered heavy weight crossbred calves at weaning (8.8 mo.) to evaluate the effects of preweaning nutritional programs on carcass and palatability traits. Calves had less subcutaneous fat, lower numerical YG, smaller REA, less KPH fat, and generally lower marbling scores than USDA Good or Choice steer carcasses, regardless of preweaning treatments. Dikeman et al. (1985a) found that steers fed on an accelerated system and slaughtered at relatively young ages (12-14 mo) had less fat thickness, smaller LD muscle areas, lower numerical YG, and lower marbling scores and QG then steers on a conventional system slaughtered at more typical (17-18 mo) ages. A subsequent study revealed that steers fed on an accelerated program and slaughtered at 12.6 or 13.8 months of age were leaner and had less marbling and lower USDA QG than 18 mo old cattle fed on a conventional two-phase system. In contrast, Lunt et al. (1987) found that heifers fed as calves were fatter, had more KPH fat, higher dressing percentages, less desirable USDA YG, and higher USDA QG than heifers fed as yearlings.

Palatability

Age of cattle at slaughter has long been thought to influence beef palatability. Some have suggested that age may influence palatability to a greater extent than more common indicators such as marbling (Alsmeyer, 1959).

Most studies dealing with the association between age and palatability have focused on tenderness as the major contributor to overall palatability. It is generally accepted that tenderness decreases with age (Dunsing, 1958; Simone et al., 1958; Alsmeyer, 1959; Tuma et al., 1962; Ramsey et al., 1965; Lunt et al., 1987). However, relatively small or insignificant differences in tenderness due to age or carcass maturity have been reported by numerous other investigators (Nelson et al., 1930; Barbella et al., 1939; Hiner et al., 1950; Romans et al., 1965; Carroll et al., 1978). Rouquette and co-workers, (1981, 1983) found grass-fed calves slaughtered at weaning (8 to 9 mo) to be less tender than older grain-fed steers. These differences were removed however, with electrical stimulation of calf carcasses. Discrepancies in the literature can often be attributed to the range of age differences studied, with relatively small differences being reported among cattle less than 24-30 months of age. While some differences may exist, most tenderness values reported for young cattle have been similar to those reported for cattle of typical slaughter age.

While flavor has been thought to improve with age (Simone et al., 1958), numerous researchers have detected no significant differences in flavor or juiciness as the result of animal age (Nelson et al., 1930; Barbella et al., 1939; Tuma, 1962; Rouquette and Carpenter 1981; Rouquette et. al., 1983; Dikeman et al., 1985 a,b; Lunt et al., 1987). It appears logical that factors such as carcass aging and cooler conditions may have a more pronounced effect upon flavor than animal age (Tuma, 1963).

The acceptability of beef produced under accelerated systems and slaughtered at relatively young ages (9-13 mo) has been the recent focus of several scientists. Rouquette and co-workers (1981, 1983) found no differences in overall palatability of heavy weanling calves and older grain-fed steers if calf carcasses were electrically stimulated. Similar findings have been reported by Dikeman et al., (1985 a,b) and Lunt et al. (1987) who cited mostly equal or superior palatability for younger cattle in an accelerated system when compared to steers from a conventional program, and concluded that accelerated management of young cattle is a viable alternative.

Cholesterol

Few findings concerning the relationship of cholesterol in beef to age at slaughter have been reported. Serum cholesterol has been shown to increase with age in dairy cattle (Tumbleson and Hutcheson, 1971; Arave et al., 1973). Stromer et al. (1966) found LD cholesterol to increase with maturity of beef carcasses, and Vanderwert et al. (1988) reported a positive correlation of .28 between age of Limousin steers and LD muscle cholesterol.

Economic Considerations For Accelerated Production Systems

Evaluating economic efficiency of beef production on a broad basis is often difficult, due to the wide variation in individual costs and practices. However, when considering accelerated and conventional beef production systems, several considerations seem particularly pertinent. Economic merit of these systems may be greatly influenced by: 1) general strengths and weaknesses of the respective systems; 2) marketing structure and pricing basis; 3) actual and relative advantages for various system x breed type interactions.

The most obvious advantages of accelerated production systems are centered around the reduced amount of time cattle must be fed. The shorter feeding period reduces total yardage and interest costs. In addition, if the commonly observed increase in feed efficiency associated with increased ADG is realized, then total feed costs and feed costs/kg gain are reduced as well, assuming feed prices remain constant. Further, reduced labor, transportation, and health costs may be realized with the shorter production cycles. A conventional system, on the other hand, may have the advantage of providing the most economically efficient use of land and forage resources.

Current industry carcass pricing structures are based upon USDA YG and QG, with substantial discounts made place for carcasses with YG greater than 4.0, or QG less than low Choice. Any premiums for superior cutability (YG 1 or 2) or higher quality (High Choice, Prime) carcasses are quite small in comparison to the previously stated discounts. In addition, discounts for carcass weights less than 270 kg or in excess of 385 kg are often levied. Thus, slaughter weight and USDA quality grade become major considerations. Tremendous variation in carcass composition may exist within USDA YG 1, 2 and 3 with little penalty or premium.

A pricing structure based on retail yield of lean meat has been frequently discussed and proposed. Such a scheme would require greater emphasis to be placed upon carcass composition, and while carcass weight and USDA quality grade would still be considered, their relative importance would be reduced.

Dikeman et al. (1985a) calculated production costs, breakeven prices and profit for large and small framed cattle on both accelerated and conventional systems. In addition, carcass value was determined based on predicted cutability differences or according to typical industry price discounts. Simmental x Chianina cattle produced under the accelerated system had the lowest break-even live price, lowest cost per kg of retail product, and were the most profitable of any cattle type x production system combination, regardless of pricing method.

Based on industry price differentials, smaller type cattle seem better suited to a conventional system. They may be either excessively fat at acceptable carcass weights, or yield light carcasses at acceptable compositional endpoints if managed in an accelerated program (Dikeman et al., 1985a; Loy et al., 1989). Larger, faster growing cattle, on the other hand, will likely be more profitable on an accelerated system (Dikeman et al., 1985a; Schmidt et al., 1987), especially if a substantial number reach the choice QG (Lambert et al., 1984). Large type breeds are less useful in conventional management systems, since they often fail to reach sufficient fatness or QG levels at acceptable weights. In addition, the increased time on feed required to reach acceptable composition makes production costs prohibitive.

If carcass value is based on retail product differences, the economic advantages of high growth potential breeds or types on an accelerated program become more pronounced (Dikeman et al., 1985a; Schmidt et al., 1987). In addition, cattle of this type may have merit if fed on a conventional system if market value is based on actual retail yield differences. Smaller framed cattle with lower genetic potential for growth would likely suffer under such a pricing system, due to their relatively low retail yield, especially if managed in accelerated programs.

Objectives

Specific strategies and optimum conditions for production of lean beef in accelerated systems have not been fully established. This experiment was therefore designed to evaluate several advantages and disadvantages of an accelerated beef production system. A primary objective was to determine palatability levels of beef produced in an accelerated system, since accelerated management typically produces less mature carcasses with lower degrees of marbling. Carcasses representing conventionally produced beef (USDA Choice QG) were randomly selected from a commercial slaughter plant for comparison to five breed types raised in an accelerated system.

Due to consumer concern about fat and cholesterol content of beef, determination of carcass composition and blood and muscle cholesterol concentrations of beef produced in accelerated systems was also an objective.

Since widely diverse cattle types may respond differently to accelerated management, an additional objective was a comparison of several cattle types raised in an accelerated system. This was addressed by utilizing steers from herds representing five biological types which were slaughtered at three weight endpoints. Breed groups were selected based on their diversity and availability. Two year's calf crops were studied to provide adequate cattle numbers. Considering these objectives, an experiment with the following null hypothesis was designed:

Biological type and slaughter weight will not affect feedlot performance, carcass composition, palatability, or cholesterol content of steers produced in an accelerated system.

Materials and Methods

Cattle Management

Two hundred four steers representing five breeding groups were utilized in a two year study to evaluate performance, carcass, palatability, and cholesterol characteristics of cattle managed in an accelerated production system and slaughtered at three weight endpoints. The steers utilized were taken from herds comprising an ongoing breeding project at the Lake City Experiment Station, Lake City, Michigan. Five distinct herds (hereafter referred to as breed groups) were involved in the breeding project. Group 1 consisted of an unselected Hereford herd in which no selection has occurred since initiation of the breeding project in 1966. Group 2 cattle originated from the same population as group 1. Selection for yearling weight has occurred since 1966. Group 2 cows were artificially bred to sires selected for superior growth traits, primarily yearling weight. A rotational cross herd consisting of three moderate size, moderate milk production breeds (Hereford, Angus, Shorthorn) comprised group 3. Selection in group 3 is for growth. A second rotational cross herd utilizing three large size, high milk production breeds (Simmental, Gelbvieh, Hostein) composed group 4. Selection occurred as in group 3. A straightbred Angus herd donated to Michigan State University in 1986 by Old Home Farm, Trenton, Ohio

Table 1. BREED GROUPS

Group		Selection criteria	Frame score	SEM
1	Unselected Herefords	None	3.0	.17
2	Selected Herefords	Growth	4.5	.18
3	Hereford x Angus x Shorthorn	Growth	5.7	.21
4	Simmental x Gelbvieh x Holstein	Growth	6.5	.24
5	Angus	Multiple	4.5	.19
6	Control carcasses (USDA Choice)	---		

Table 2. TARGET SLAUGHTER WEIGHTS (kg)

	Breed group				
Slaughter Group	1	2	3	4	5
1	350	385	455	455	385
2	400	455	535	535	455
3	445	525	615	615	525

formed group 5. Multiple trait selection for maternal ability, fertility, and yearling weight has occurred since the mid 1960's. A summary of breed groups and estimated frame scores is given in Table 1. Each breed group was represented by approximately equal numbers of cattle.

Upon weaning, all calves were weighed and trucked 220 km to the test facility. Weights were also taken the following day, and the average of the two was recorded as the initial weight. Calves were allotted by initial weight within breed group to three slaughter groups (Table 2). At weaning, all calves were vaccinated for clostridial and respiratory diseases, treated for internal and external parasites and given an implant containing estradiol and progesterone. Hip height was recorded to confirm frame scores, and blood samples were taken via jugular venipuncture for serum cholesterol determination. Cattle were housed in a covered, open sided slatted floor facility in 3.0 x 4.8 meter pens from weaning until slaughter.

All steers were adjusted to an 80% concentrate diet (Table 3) within 21d post-weaning. Ad libitum feed was supplied to each pen once daily. Pen feed refusals were collected and weighed weekly. Cattle were weighed prior to feeding at 28d intervals from weaning until slaughter. A total of 13 animals died or were removed from trial due to chronic sickness or injury during the

Table 3. DIET COMPOSITION (DMB)

Crude protein, %	12.7
NEg, Mcal/kg	1.38
	%
Corn Silage	15.0
Alfalfa Hay	5.0
High Moisture Corn	73.4
Supplement	6.6
	100.0

two year period.

Slaughter Procedures and Carcass Composition Determination

When target slaughter weights were reached, cattle were weighed on two consecutive days and the average recorded as the final weight. Hip height was also recorded, and blood sera samples were collected as described previously. On the day of slaughter, steers were loaded early in the day, transported 114 km to a commercial slaughter facility, and immediately slaughtered.

Carcasses were ribbed approximately 24 h postmortem. Carcass weight, fat thickness, ribeye area, and calculated YG were recorded for each carcass. Maturity, marbling score, QG, and % KPH were determined by a federal grader approximately five h after ribbing. Control carcasses were obtained at each slaughter time. Seven carcasses per SG were randomly selected from among carcasses available at the slaughter facility. The sole criteria for selection was that carcasses fulfill the minimum requirements for low Choice quality grade.

In order to accommodate slaughter plant personnel, a seven rib section was removed from the left side of each carcass. The rib section was immediately placed in a plastic bag and transported to the Michigan State University meats laboratory for further processing. Steaks were removed from the posterior end (12th rib) of the rib section, uniformly trimmed to 4.4 cm thickness, vacuum packaged in freezer bags and stored at -30 C until taste panel tests were performed. The portion trimmed from the steaks was stored in the same manner for subsequent cholesterol analyses.

The 9-10-11 rib section was prepared as described by Hankins and Howe (1946). The rib section was deboned and the soft tissue ground three times. The sample was mixed thoroughly by hand between grindings. A 300g sample of the ground tissue was collected in a Whirlpack sample bag and stored at -30 C until analysis. Rib samples were frozen in liquid nitrogen and thoroughly homogenized in a large Waring blender prior to determination of dry matter, protein, or fat content.

The remaining three rib section was processed and marketed through the Michigan State University meats laboratory.

Sample dry matter was determined by drying duplicate samples in a forced air oven for 48 h at 60 C (AOAC, 1984). Crude protein content of duplicate samples was calculated from total nitrogen as determined by the Kjeldahl procedure using a Technicon auto-analyzer system (AOAC, 1984). Fat content of each sample was determined in triplicate by ether extraction for 12 hours in a Soxhlet apparatus. Percentage carcass fat and protein were estimated from rib fat and protein using the equations of Hankins and Howe (1946).

Taste Panel Procedures

A 12-member trained taste panel was used for palatability determination of rib steaks. Panel members were selected from among MSU faculty and staff trained according to AMSA guidelines (1978).

Steaks were thawed for 16 h at 4 C and broiled on Farberware broilers to an internal temperature of 70 C. Steaks were cooled for 24 h at 4 C. Core samples 2.54 cm in diameter were then removed from the steaks and served cold. Four randomly selected steaks were sampled and served at each session, and no more than two sessions were held per day. Core samples 1.27 cm in diameter were also removed from each steak for Warner-Bratzler shear force determination. The average of 12 measurements was recorded for each steak.

Cholesterol Analyses

Blood serum samples collected at weaning and slaughter were stored at 20 C for 2-4 h, and then stored overnight at 4 C. Blood sera were obtained the following day by centrifugation at 2000 x g for 20 minutes. Sera were stored at -20 C until analyzed for total cholesterol. Samples were analyzed for total cholesterol according to a modification of the enzymatic method of Allain et al. (1974; Sigma Diagnostics Cholesterol Procedure No. 352, 1988). LD muscle samples were analyzed for total cholesterol using the direct saponification method of Adams et al. (1987), modified by omitting derivitization of the extract (Engeseth and Gray, 1989).

Statistical Analyses

Data were analyzed by analysis of variance with year, breed group and slaughter endpoint as main effects. All two-way interactions were included in the model. Analyses were performed using the General Linear Models procedure on the Statistical Analysis System (SAS, 1987). Specific contrasts were designed to compare BG 1-5 vs controls, BG 1 vs BG 2, BG 2 and 5 vs BG 3 and 4, BG 2 vs 5, BG 3 vs 4, SG 1 vs SG 2, and SG 2 vs SG 3.

Economic Analyses

Cost of production, breakeven price, and profit or loss were estimated for cattle in the accelerated system and for similar steers from previous years managed in a more conventional manner. Since cow costs were not available for the purebred Angus herd, breed group 5 was not included in the economic analyses. Data from steer progeny of BG 1, 2, 3 and 4 from 1978 - 1982 were used for comparison to the accelerated system due to the genetic similarity of the cattle and the availability of data. Steers in these years were placed on a moderate to high (50-80%) concentrate diet immediately after weaning and slaughtered when it was estimated that 80% of the cattle would grade USDA Choice.

Total variable cow costs were used as an estimate for preweaning costs of production. A review of literature revealed that feed costs comprise approximately 70% of total variable cow costs. Based on this assumption, total variable cow costs were calculated as total cow feed costs (Ritchie et al., 1986) divided by .70. Trucking costs were calculated based on a $1.80 per loaded mile fee. Processing and medical costs were $4.50 per head and yardage charge was $.25 per head per day. Interest costs were assumed to be a component of total variable cow costs and were therefore not estimated separately. Cost of the feedlot diet was calculated to be $.026/kg of DM. Cost of feedlot feed was calculated by multiplying total feedlot gain (kg) times feed conversion ratio (DM basis) times $.026.

Carcass prices were based on 2 year historical prices. Choice and Select carcasses were priced at $161.80/100 kg and $246.40/100 kg, respectively. An adjustment of $8.81/100 kg was made for each full yield grade above or below 3.0 to reflect value differences of estimated retail product percentages. Carcasses weighing over 386 kg or under 248 kg were discounted $4.41/100 kg.

Industry price differentials were used for an additional analysis (II) of cattle in the accelerated system. Yield grade 4 & 5 carcasses were discounted

$24.77/100 kg, and yield grade 1 and 2 carcasses received a premium of $4.41/100 kg. The same quality grade prices and discounts for light and heavy carcasses were used as in analysis I.

Results

Feedlot Performance

A summary of weight gain and feed conversion efficiency is presented in Table 4. Steers in BG 1 were lightest initially, and crossbred cattle (BG 3 and 4) were heavier than the selected Hereford (BG 2) and Angus (BG 5) steers. A significant ($p<.05$) BG x SG interaction existed for feelot ADG. Least squares means are listed in Table 6. ADG decreased with time on feed in BG 2, 4 and 5. BG 1 and 3 had similar ADG in SG 1 and SG 3. Unselected Herefords were consistently the slowest gaining regardless of SG. ADG was similar for the other four SG. Feed conversion (DMI gain) became poorer with SG (Table 5). Specific contrasts were performed for BG 1 vs 2 and 5, 2 and 5 vs 3 and 4, 2 vs 5, and 3 vs 4. There were no significant differences in F:G detected by these contrasts. BG 1 had the most desirable F:G ratio numerically. Slaughter weights were reflective of the design.

Carcass Characteristics

Differences in carcass weight reflected slaughter weight and experimental design. Significant BG x SG interactions existed for REA, QG, KPH and YG (Table 9). BG1 in SG 1 and 2 had numerically smaller REA and higher numerical YG than the other groups. BG 4 consistently had the most desirable YG. Subcutaneous fat thickness

Table 4. LEAST SQUARES MEANS FOR BREED GROUP WEIGHTS AND FEED CONVERSION (kg)

	Breed Group					
Item	1	2	3	4	5	SEM
Initial Weight, (kg)	163	222	262	275	203	2.23
Final Weight, (kg)	401	458	525	528	430	5.13
Feed Conversion (Feed/Gain)[a]	5.51	5.76	6.23	6.44	5.61	.135

[a] Breed Group contrasts 1 vs 2; 2 and 5 vs 3 and 4; 2 vs 5; 3 vs 4 were not significant (p>.10).

Table 5. SLAUGHTER GROUP LEAST SQUARES MEANS FOR FEEDLOT WEIGHTS AND FEED CONVERSION (kg).

Item	Slaughter Group 1	2	3	SEM
Initial Weight, kg	198[a]	227[b]	251[c]	1.73
Final Weight, kg	412[a]	466[b]	527[c]	3.98
Feed Conversion (Feed/Gain)a	5.37[a]	5.90[b]	6.46[c]	.10

[a,b,c] Means within a row differ ($p<.05$).

Table 6. BREED GROUP x SLAUGHTER GROUP LEAST SQUARES MEANS FOR FEEDLOT ADG, (kg)[a]

SG	Breed Group 1	2	3	4	5
1	1.08	1.36	1.38	1.44	1.37
2	1.18	1.32	1.26	1.28	1.41
3	1.09	1.29	1.35	1.22	1.29

[a] MSE =.258

Table 7. LEAST SQUARES MEANS FOR BREED GROUP CARCASS CHARACTERISTICS

	Breed Group						
Item	1	2	3	4	5	6	SEM
Carcass Weight, kg	242	281	325	322	261	308	3.8
12th Rib Fat, cm	1.21	1.11[b]	1.10[c]	.69[cd]	1.13[b]	1.15	.06
Ribeye Area, cm^2	70.24	75.0	82.9	87.3	72.3	81.2	1.19
Quality Grade [a]	11.5	11.4	11.7	11.7	11.8	12.8	.12
Yield Grade	2.78	2.61	2.73	2.06	2.69	2.74	.09

[a] 11=select$^+$, 12=Choice$^-$, etc.

[b,c,d] Breed contrasts 2 and 5 vs 3 and 4; 3 vs 4. Means within row with different superscripts differ ($p<.05$).

Table 8. LEAST SQUARES MEANS FOR SLAUGHTER GROUP CARCASS CHARACTERISTICS

Item	Slaughter Group 1	Slaughter Group 2	Slaughter Group 3	SEM
Age, mo	11.6	13.0	14.4	---
Carcass Weight, kg	257	290	323	2.7
Backfat, cm	.94[b]	1.05[c]	1.20[d]	.04
Ribeye Area, cm^2	73.66	78.06	83.74	.84
Quality Grade[a]	11.6	11.6	12.2	.09
Yeild Grade	2.34	2.62	2.85	.06

[a] 11=Select$^+$, 12=Choice$^-$

[b,c,d] Means within row with different superscripts differ, ($p<.05$)

Table 9. BREED GROUP x SLAUGHTER GROUP LEAST SQUARES MEANS FOR SELECTED CARCASS CHARACTERISTICS

	Breed Group				
	1	2	3	4	5
Slaughter Group 1					
Ribeye Area, cm^2 [a]	65.7	71.0	73.4	84.3	66.4
Yield Grade[b]	2.6	2.2	2.7	1.7	2.3
Quality Grade[ce]	11.0	11.3	11.8	11.2	11.8
Carcass fat[d], %	32.4	26.5	31.6	27.7	31.7
Slaughter Group 2					
Ribeye Area, cm^2	68.8	75.7	82.9	87.3	73.8
Yield Grade	2.8	2.4	2.9	2.1	2.7
Quality Grade	11.2	11.1	11.4	11.4	12.0
Carcass fat, %	31.2	31.5	34.0	28.2	31.4
Slaughter Group 3					
Ribeye Area, cm^2	76.2	78.3	92.4	90.2	76.8
Yield Grade	2.9	3.3	2.6	2.4	3.0
Quality Grade	12.3	11.7	12.1	12.4	11.7
Carcass fat, %	35.4	35.7	32.2	33.7	33.5

[a] MSE = 3.4 [b] MSE = .85 [c] MSE = 1.3 [d] MSE = 61.2

[e] 11=Select$^+$, 12=Choice$^-$, etc.

increased with SG in all breed groups (Table 8). Table 7 gives carcass characteristics by breed group. BG 2 and 5 had significantly more backfat than BG 3 and 4, and BG 4 cattle were leanest regardless of SG. Contrasts revealed no differences ($p<.05$) in fat thickness between accelerated and control carcasses. Cattle on the accelerated program had less marbling and lower QG than controls. Specific contrasts revealed lower marbling scores for BG 2 than for BG 5. Marbling scores and quality grades were not significantly different among SG 1 and 2 (Table 8), but were higher for SG 3. Cattle on the accelerated system failed to reach the USDA Choice QG until the third slaughter period.

Carcass Composition

Estimated percentages of carcass fat and protein are given in Tables 10 and 11, respectively. BG x SG interactions were significant for both carcass fat and carcass protein. Carcass fat increased with SG.

BG 4 carcasses had the lowest percentages of carcass fat, and accelerated carcasses had slightly less fat than controls. Estimates of carcass protein were inversely related to carcass fat.

Palatability Traits

No significant interactions were observed for any palatability traits. Means for tenderness (Tnd), juiciness (Juc), flavor (Fla), overall satisfaction (OS)

Table 10. BREED GROUP x SLAUGHTER GROUP LEAST SQUARES MEANS FOR ESTIMATED CARCASS FAT (%)[a]

	Breed Group					
Slaughter Group	1	2	3	4	5	6[b]
1	32.4	26.5	31.6	27.7	31.7	33.9
2	31.2	31.5	34.0	28.2	31.4	
3	35.4	35.7	32.2	33.7	33.5	

[a] MSE = 61.2

[b] Average of all controls

Table 11. BREED GROUP x SLAUGHTER GROUP LEAST SQUARES MEANS FOR ESTIMATED CARCASS PROTEIN, (%)[a]

	Breed Group					
Slaughter Group	1	2	3	4	5	6[b]
1	12.8	14.7	13.2	14.1	14.2	12.6
2	12.3	13.6	12.5	14.3	12.8	
3	12.2	12.2	12.9	12.8	12.2	

[a] MSE = 5.3

[b] Average of all controls.

Table 12. LEAST SQUARES MEANS FOR BREED GROUP PALATABILITY CHARACTERISTICS[a]

	Breed Group						
Item	1	2	3	4	5	6	SEM
Tenderness	6.12	6.26	5.95	5.73	6.27	5.82	.141
Juiciness	5.90	6.11	6.04	6.00	5.95	6.05	.156
Flavor	6.05	6.21	6.18	6.04	6.04	6.03	.084
Overall Satisfaction	5.98	6.21	6.04	5.95	6.15	5.95	.110
Warner-Bratzler Shear, kg	3.44	3.37	3.62	3.52	3.35	3.49	.110

[a] Based on taste panel scale of 1-9. 1=extremely undesirable 9=extremely desirable

and Warner-Bratzler Shear force (WBS) are presented by BG in Table 12. SG means are given in (Table 13). There were no significant differences due to main effects for any palatability trait (Table 14), although controls were numerically less tender than the pooled average of the accelerated groups, and this difference approached significance ($p = .12$).

Cholesterol Measures

Blood serum cholesterol measured at weaning did not differ with BG or SG (Table 15, 16). Cholesterol concentration at weaning was significantly lower ($p<.05$) in the second year. Differences in serum cholesterol at weaning and slaughter were small and inconsistent across breed groups. BG 1 had the highest serum cholesterol concentration at slaughter (144 mg/dl), and the contrast of BG 1 vs BG 2 and 5 was significant ($p<.05$). Contrasts of BG 2 and 5 vs 3 and 4, BG 2 vs 5 and 3 vs 4 were not significant for serum cholesterol at slaughter. SG means for serum cholesterol are listed in Table 16. Serum cholesterol measure at slaughter increased significantly with each successive slaughter time.

Table 17 gives BG means for LD muscle cholesterol. Cholesterol extracted from LD muscle tissue was not influenced by BG ($p>.1$). Cattle in SG 3 had significantly higher ($p<.05$) LD cholesterol concentrations than those in SG 1 or 2 (Table 18).

Correlation coefficients for cholesterol and other

Table 13. LEAST SQUARES MEANS FOR SLAUGHTER GROUP PALATABILITY CHARACTERISTICS[a]

	Slaughter Group			
Item	1	2	3	SEM
Tenderness	5.91	6.02	6.15	.110
Juiciness	6.04	5.91	6.08	.111
Flavor	6.04	6.08	6.16	.06
Overall Satisfaction	6.01	6.03	6.11	.078
Warner-Bratzler Shear, kg	3.57	3.49	3.34	.078

[a] Based on taste panel scale of 1-9. 1=extremely undesirable, 9= extremely desirable

Table 14. LEAST SQUARES MEANS FOR ACCELERATED AND CONTROL PALATABILITY CHARACTERISTICS[a]

	Breed Group		
Item	Accelerated	Control	SEM
Tenderness	6.07[b]	5.82[c]	.153
Juiciness	6.00	6.05	.156
Flavor	6.10	6.03	.084
Overall Satisfaction	6.07	5.96	.110
Warner-Bratzler Shear, kg	3.46	3.49	.110

[a] Based on taste panel scale of 1-9. 1=extremely undesirable, 9=extremely desirable

[b,c] $p=.12$

Table 15. LEAST SQUARES MEANS FOR BREED GROUP SERUM CHOLESTEROL (mg/dl)

	Breed Group					
Sampling Time	1	2	3	4	5	SEM
Weaning	124	128	125	135	125	4.6
Slaughter	144[a]	128[b]	124	118	127	4.2

a,b BG contrast 1 vs. 2 $p<.05$.

Table 16. LEAST SQUARES MEANS FOR SLAUGHTER GROUP SERUM CHOLESTEROL (mg/dl)

	Slaughter Group			
Sampling Time	1	2	3	SEM
Weaning	129	128	126	3.2
Slaughter	108[a]	131[b]	146[c]	3.8

a,b,c $p<.01$.

Table 17. LEAST SQUARES MEANS FOR BREED GROUP LONGISSIMUS DORSI MUSCLE CHOLESTEROL

	Breed Group						
	1	2	3	4	5	6	SEM
Cholesterol mg/100g[a]	74.1	72.7	70.8	72.0	67.4	75.2	2.4

[a] wet tissue basis.

Table 18. SLAUGHTER GROUP LEAST SQUARES MEANS FOR MUSCLE CHOLESTEROL

	Slaughter Group			
	1	2	3	SEM
Cholesterol, mg/100g[a]	70.2[b]	69.3[b]	76.6[c]	1.7

[a] wet tissue basis.

[b,c] $p<.05$

variables are given in Table 19. Serum cholesterol at weaning was positively and significantly correlated with serum cholesterol at slaughter, fat thickness and YG, and negatively correlated with marbling and QG. Similar relationships were observed for blood cholesterol measured at slaughter. LD muscle cholesterol was not correlated to any measure of carcass fatness or serum cholesterol.

Economic Analysis

Group 1 steers on the accelerated program had the lowest preweaning cost of any of the four breed groups. Production costs and returns for steers on the accelerated program are presented in Table 20. Preweaning costs reflected cow feed costs, and increased as cow size increased. Feedlot feed costs were lowest for BG 1 steers, similar for BG 3 and 4, with BG 2 intermediate. Total estimated production costs were lowest for breed group 1 and increased with each successive breed group, reflecting feed costs. Breakeven live price was lowest for BG 2 steers ($1.38/kg), equal for BG 1 and 3 ($1.43/kg) and highest for BG 4 ($1.46/kg). BG 2 had the lowest cost/kg of predicted retail product ($2.97/kg), while BG 3 and 4 were equal ($3.05/kg) and BG 1 steers had the highest ($3.13/kg). When carcass value was calculated using industry price differentials, BG 2 steers were the most profitable ($89.94/hd), followed by the crossbred groups

Table 19. CORRELATION COEFFICIENTS BETWEEN CHOLESTEROL CONCENTRATIONS AND OTHER FACTORS

Item	LD Cholesterol	Serum Cholesterol, Weaning	Serum Cholesterol, Slaughter
LD Cholesterol	---	NS	NS
Serum Cholesterol, Weaning	NS	---	.13[b]
Serum Cholesterol, Slaughter	NS	.13[b]	---
Fat Thickness	NS	.30[a]	.29[a]
YG	NS	.37[a]	.37[a]
Marbling	NS	-.18[a]	NS
QG	NS	-.2[a]	NS

[a] $p<.05$ [b] $p<.10$ NS - Not Significant

Table 20. PRODUCTION COSTS AND RETURNS FOR CATTLE IN ACCELERATED SYSTEM[a]

Item	1	2	3	4
Initial Weight, kg	163	222	262	275
Preweaning Production Cost, [b]	351.57	404.47	488.34	509.85
Transportation[c]	2.33	2.33	2.33	2.33
Processing[d]	4.50	4.50	4.50	4.50
Days on Feed	183	183	183	183
Yardage[e]	45.75	45.75	45.75	45.75
Feelot Feed Cost	168.33	174.90	209.28	209.56
Total Cost	572.48	631.95	750.20	771.99
Final Weight, kg	401	458	525	528
Carcass Weight, kg	242	281	325	322
Breakeven Live Price $/kg	1.43	1.38	1.43	1.46
Cost/kg Retail Product	3.13	2.97	3.05	3.05
Carcass Value I[f]	607.44	721.89	826.48	842.35
Carcass Value II[g]	608.85	719.17	843.70	854.76
Profit [Loss] I	34.96	89.94	76.28	70.36
Profit [Loss] II	36.37	87.22	93.50	82.77

[a] Values are $/head unless otherwise indicated.

[b] Total variable cow cost as estimated from cow feed costs/.70

[c] Based on $1.80 per loaded mile

[d] Does not include labor costs

[e] $.25/hd/d

[f] Based on industry price differentials of $24.77/100 kg discount for YG 4 and 5 carcasses, $4.41/100 kg premium for 1 and 2 carcasses, and $4.41/100 kg discount for carcasses over 386 kg and 248 kg. Choice and Select carcasses priced at $261.80/100 kg and $2.46.40/100 kg respectively.

[g] Price differentials based on $8.81/100 kg adjustment for each full YG above or below 3.0 and $4.41 discount for carcass above 386 kg or below 246 kg. Choice and Select carcasses priced at $261.80/100 kg and $246.40/100 kg, respectively.

($76.28/hd and $70.36/hd for BG 3 and 4, respectively), with BG 1 cattle yielding the least profit ($34.96/hd). Steers from BG 3 yielded the most profit ($93.50/hd) of any BG when carcass value was based on a standard adjustment for YG. Steers in BG 2 and 4 produced similar profit ($87.22/hd and $82.77/hd, respectively) and BG 1 produced by far the least ($36.37/hd) when using this pricing method.

Breakeven live price and cost/kg. retail product were decreased with each slaughter time in all breed groups in the accelerated program. Profits in all breed groups were increased in each successive slaughter group (Table 21).

In order to evaluate the effects of post-weaning management on economic performance, preweaning costs were assumed to be the same for cattle on the accelerated system as for those raised in the previous years. Total estimated production costs for steers in 1978-1982 were somewhat higher than for steers in the accelerated program due to the longer feeding period and additional feed costs. The rankings were not different, however. Costs and returns for 1978-1982 steers are presented in Table 22. Breakeven live price was lowest for BG 2 (1.42/kg.) and similar for BG 1, 3 and 4 ($1.47/kg., $1.48/kg. and $1.47/kg.). Cost per kg. of predicted retail product was lower for larger mature size cattle ($4.15/kg., $4.22/kg., $4.30/kg. and

TABLE 21. COSTS AND RETURNS FOR LAKE CITY STEERS MANAGED CONVENTIONALLY (1978-82)[a]

Item	1	2	3	4
Initial wt., kg.	176	212	251	275
Prewean. Prod. Cost[b]	351.57	404.47	488.34	509.85
Transport[c]	2.33	2.33	2.33	2.33
Processing[d]	4.50	4.50	4.50	4.50
Days on Feed	297	297	297	297
Yardage[e]	74.25	74.25	74.25	74
.25				
Total Feed Cost	224.52	263.38	306.94	310.47
Total Cost	657.17	748.93	876.36	901.40
Final weight, kg.	446	527	590	612
Breakeven Live Price, $/kg	1.47	1.42	1.48	1.47
Cost/kg Retail Product	4.53	4.30	4.22	4.15
Carcass Value II[f]	681.75	809.44	913.46	956.46
Profit [Loss] II	24.58	60.51	37.10	55.06

[a] Values are $/head unless otherwise specified.

[b] Total variable cow cost as estimated from cow feed costs/.70

[c] Based on $1.80 per loaded mile

[d] Does not include labor costs

[e] $.25/hd/d

[f] Based on industry price differentials of $24.77/100 kg discount for YG 4 and 5 carcasses, $4.41/100 kg premium for 1 and 2 carcasses, and $4.41/100 kg discount for carcasses over 386 kg and 248 kg. Choice and Select carcasses priced at $261.80/100 kg and $2.46.40/100 kg respectively.

Table 22. BREED GROUP AND SLAUGHTER GROUP BREAKEVEN LIVE PRICES, COSTS/KG RETAIL PRODUCT AND PROFIT OR LOSS

Item												
Breed Group	1			2			3			4		
Slaughter Group	1	2	3	1	2	3	1	2	3	1	2	3
Breakeven Live Price, $/kg	1.50	1.44	1.40	1.48	1.42	1.30	1.55	1.43	1.37	1.52	1.47	1.44
Cost/kg Retail Product	3.26	3.14	3.02	3.07	3.00	2.86	3.32	3.07	2.84	3.14	3.02	3.01
Profit [Loss] [a,b]	[8.21]	25.72	99.35	10.13	45.66	154.72	11.60	76.56	157.39	[1.21]	56.87	84.20
Profit [Loss] [c]	[.57]	20.77	93.08	26.89	51.52	145.98	19.84	68.76	170.30	18.61	68.11	100.43

$4.53/kg. for BG 4, 3, 2 and 1 respectively). Steers from BG 2 and 4 were the most profitable ($60.51/hd and $55.06/hd) when carcass value was based on a consistent adjustment for YG. Data necessary for calculation of carcass value based on industry price differentials were unavailable for 1978 - 1982 steers.

Discussion

Differences in initial weight of the five breed groups reflect the diversity of the breeds, as all steers were raised and managed at the same location and under similar conditions prior to weaning.

Decreases in ADG and feed efficiency with time on feed have been frequently reported. The heavier body weights associated with each successive SG resulted in higher maintenance requirements and reduced ADG. In addition, cattle were likely accreting proportionately more fat with additional time on feed, an energetically expensive process on a weight basis (Thorbek, 1977) which may reduce feed efficiency. This would be particularly true for the more physiologically mature purebred breed groups.

The dramatically lower (19% less) ADG of the BG 1 steers as compared to the average of the other BG dramatically illustrates the effect of selection for growth. The similar ADG across SG by the four selected BG is interesting, since some differences might have been expected due to breed type diversity. Some insight into this can be gained by examining the BG x SG interaction for ADG. Large-framed crossbred steers (BG 3 and 4) in SG 1 posted the highest numerical ADG, in agreement with the findings of numerous researchers (Koch et al., 1976; Prior et al., 1977; Ferrell and Crouse, 1978; Dikeman et al., 1985a and b). However, BG

3 and BG 4 steers in SG 2 gained 9.5 and 12.5% slower, respectively, than their counterparts in SG 1. There was little if any reduction in ADG between SG 1 and SG 2 steers of other breed groups. This trend continued in BG 4, as SG 3 steers gained 18% slower than in SG 1, the largest reduction in gain of any BG. These findings are somewhat unexpected, as larger mature size, physiologically less mature cattle have been reported to sustain greater ADG over longer periods of time than smaller breed types of similar chronological age (Koch et al., 1976; Prior et al., 1977; Smith et al., 1977).

The reduction in ADG of the BG 4 steers may be related to feed conversion, as they were the least efficient of any breed group, although differences were not statistically significant. It is doubtful, therefore, that this would explain the drastic reduction in ADG which occurred. It is more likely that reduced ADG of crossbred steers in SG 2 and 3 is related to stress associated with the confinement facilities. The crossbred steers, especially BG 4, were much more susceptible to structural unsoundness and stiffness than the purebred groups, especially at the heavier weights associated with SG 2 and 3.

Final weights of all BG x SG combinations reflected the predetermined target weights. Of particular interest are the relatively light slaughter weights of BG 1 steers, which are somewhat below typical industry standards.

Carcass weights were representative of slaughter live weights in all breed groups. BG 1 carcasses would probably be discounted by industry operators due to their light weights (242 kg).

The increases in CW, 12th rib fat, and REA in each successive slaughter group are expected and have been typically reported. Carcasses produced in the accelerated management system did not have sufficient marbling to reach low Choice QG until SG 3. This may be due to the relatively young age at which the cattle were slaughtered (11.6, 13.0, 14.4 mo). Indicators of fatness for SG 2 cattle would typically be associated with higher marbling and QG scores than were observed.

BG x SG interactions for carcass traits illustrate the extreme differences in biological type between BG 4 and BG 1. BG 1 steers in SG 1 and 2 had 14% more carcass fat and 27% smaller REA than BG 4 steers in these SG, differences which were reflected in YG. These differences were less dramatic in SG 3. Carcass characteristics of BG 2 and 5 were similar except for QG, which favored BG 5.

Estimates of carcass fat and protein provide insight into differences among BG x SG combinations. The greatest increases in carcass fat were noted between SG 2 and SG 3 for all breed groups except BG 3. This finding is in general agreement with the work of Ramsey et al. (1967), Bowling et al. (1978) and Dikeman et al. (1985). Thus, estimated carcass fat closely paralleled the differences in marbling and QG observed in this study. The moderate sized crossbred cattle (BG 3) in SG 2 had slightly more carcass fat than the same group allotted to SG 3, in contrast to the other breed groups. No explanation of this discrepancy is immediately apparent. Selected Hereford (BG 2) steer carcasses in SG 1 inexplicably had the lowest percentage of carcass fat of any BG x SG combination.

Carcass protein was inversely related to carcass fat, as expected (Dikeman et al., 1985a,b). The slightly higher protein and lower fat in BG 4 carcasses may be indicative of their physiological immaturity relative to the other BG.

Carcass data suggest that the crossbred cattle in this trial may be more suited for use in accelerated systems than the British purebreds due to their superior leanness and muscling if QG can be sacrificed. Similar conclusions have been reported by Byers and Rompala, (1979b), Schalles et al. (1983) and Dikeman et al. (1985). The consistently fatter, lighter, less muscular BG 1 cattle appear to have no advantages over the other cattle in the accelerated system based on carcass data from this study.

Cattle fed on the accelerated system until SG 3 produced carcasses similar in composition to the controls. There appears to be little advantage for SG 3 over SG 2 regardless of breed if QG is not considered. Such conclusions are strengthened if one considers BG 4 cattle allotted to SG 1 and 2. These cattle produced carcasses with 5.7% less fat than controls.

The marked similarity of taste panel values for all palatability traits suggests that breed type does not affect eating quality. This is in agreement with the findings of Aberle et al. (1981), Koch et al. (1981) and Crouse et al. (1985). In addition, the values are slightly higher then the midpoint of the scale in all taste panel traits, providing further evidence of the acceptability of beef produced in accelerated systems. No significant differences in palatability traits were found between SG, although all values improved numerically in each successive SG. The validity of the taste panel scores for tenderness was supported by the similarity of WBS values.

Some differences in palatability traits, particularly tenderness might have been expected based on differences in carcass characteristics. BG 4 carcasses may have been more susceptible to cold induced toughening based upon their lower amount of subcutaneous fat. However, their heavier carcass weights and minimal fat thickness seem to have prevented this effect, although they received the lowest numerical taste panel tenderness scores of any BG. This trend was not confirmed by WBS value, however. Differences in marbling and QG were not reflected in palatability scores, in agreement with the work of Blumer (1963), Campion et al. (1975), and Parrish (1981). The lack of differences in tenderness between SG is not uncommon, since the range in slaughter age was quite small (2.8 mo) among relatively young cattle (Dikeman et al., 1985; Romans et al., 1965). In addition, the controlled and consistent cooking procedures used have often resulted in less variation amoung steaks than that found at the consumer level.

Cattle on the accelerated system were slaughtered at presumably younger ages than controls (maturity A35 versus A56). However, no differences in palatability were noted between the accelerated groups and controls, although the poorer tenderness values for controls approached significance ($p = .12$). Thus, this study seems to support the conclusion that beef produced in accelerated systems is acceptable in palatability, in agreement with Rouquette et al. (1981, 1983), Lunt et al. (1987), and Dikeman et al. (1985 a,b).

Cholesterol

Serum cholesterol concentrations measured at weaning are in general agreement with reported values, although few studies have measured this variable in young cattle. The consistency of serum cholesterol values across breed groups at weaning is in contrast to the report of Wheeler et al. (1987). Serum cholesterol concentrations did not change consistently or significantly from weaning to slaughter when pooled across SG. This observation is in contrast to the work of several authors who found serum cholesterol to increase with age or time on feed (Arave et al., 1973; Tumbleson and Hutcheson, 1977; Wheeler et al., 1987). These studies were all performed using more mature cattle sampled over shorter time intervals, however.

The significant increase in serum cholesterol in successive slaughter groups however, is in agreement with these authors' findings and is more readily comparable to their studies since animal age and sampling time are similar. In addition, Edfors-Lilja et al. (1978) found a positive relationship between serum cholesterol and age. This increase in serum cholesterol with SG is coincident with the increases in fatness observed among slaughter groups, and lends credence to the hypothesis of Claesson and Hansson (1956) that serum cholesterol in cattle is closely related to lipid metabolism.

Serum cholesterol values at slaughter were slightly lower than those reported by Wheeler et al. (1987) and by Rouse and Beitz, (1988), but similar to those of Vanderwert et al., (1988).

Serum cholesterol at slaughter was significantly higher for BG 1 steers than BG 2 and 5. The unselected

Hereford steers had the highest serum cholesterol concentration of any BG at slaughter (144 mg/dl). Contrasts comparing the other four BG revealed no significant differences in serum cholesterol at slaughter. These observations are in agreement with those Rouse and Beitz (1988) who reported no differences in serum cholesterol among cattle of three frame sizes. Wheeler et al. (1987) however, showed lower serum cholesterol concentrations in Chianina steers than in British crossbreds. The authors concluded that the differences were related to lipid metabolism and fat deposition.

Cholesterol concentrations in LD muscle were somewhat higher than those reported by several previous researchers (Stromer et al., 1966; Rhee et al., 1982b; Eichorn et al., 1986b; Wheeler et al., 1987). The direct saponification procedure used in this study, however, has frequently yielded slightly higher values than those derived from more commonly used extraction procedures (Engeseth and Gray, 1989). Rouse and Beitz (1988) reported substantially higher cholesterol concentrations in LD muscle samples from cattle of three frame sizes than found in the present study. Pihl (1952) and Vanderwert et al. (1988), reported muscle cholesterol concentrations which were similar to those observed in this study. Discrepancies in reported values may be attributed to incomplete lipid extraction, imprecise quantification of the cholesterol, or infrequent differences in expression of results.

No differences in LD muscle cholesterol were observed among BG. This finding reflects the observations of numerous researchers comparing widely diverse cattle types. Eichhorn et al. (1986) reported no variation in LD cholesterol of 15 breeds or crosses of mature cows, as did Koch et al. (1987) and Wheeler et al. (1987) when comparing several extremely diverse beef breeds and Bison. Most recently, Rouse and Beitz (1988) found no differences in LD cholesterol of steers representing three frame sizes.

The higher muscle cholesterol concentration observed in SG 3 steers is not readily explainable. Stromer et al. (1966) found higher LD cholesterol in more mature beef carcasses, and Vanderwert et al. (1988) reported a positive correlation of .28 between age of Limousin steers and muscle cholesterol concentration. It seems unlikely that age is the causative factor in this study, however, as all steers involved were relatively young and the range in age between SG was relatively small (2.8 mo). Vanderwert et al. (1988), and Rouse and Beitz (1988) reported correlations of .57 and .31, respectively, between LD cholesterol and intramuscular lipid content of steer carcasses. These findings provide support to the work of Farkas et al. (1973) who concluded that adipose tissue of rats stored cholesterol in excess of amounts needed for cellular functions. Thus, increases in intramuscular fat might yield increased cholesterol content in muscle extraction samples. It is uncertain whether this theory is valid for bovine tissues, however. Further, this hypothesis is in conflict with the findings of Rhee et al. (1982b) and Thompson et al. (1988), who reported no differences in muscle cholesterol due to degree of marbling. Wheeler et al. (1987) similarly observed no differences in LD cholesterol among cattle of different types fed for varying time periods. These and other authors suggest that muscle tissue cholesterol is a function of cellular metabolism, rather than more measurable variables such as genetics or carcass characteristics.

The correlation analyses lend support to this explanation. Longissimus dorsi muscle cholesterol was not significantly correlated to any other measure of cholesterol or numerous carcass characteristics, in agreement with the findings of Wheeler et al. (1987). Vanderwert et al. (1988) and Rouse and Beitz (1988) likewise found no correlation between serum and muscle cholesterol. Thus, the conclusion that serum cholesterol is a poor indicator of beef muscle cholesterol seems to be well established. Since cholesterol is a component of cellular membranes, and cholesterol metabolism is regulated by the liver, the theory that muscle cholesterol is a product of cellular function and therefore not readily influenced by external factors appears most valid. Further, if one considers that muscle cells provide more surface area of membrane structures per unit of LD muscle weight than do fat cells, then lack of reported differences in cholesterol content of samples varying in marbling is not unexpected.

Economic Analysis

The lower costs associated with BG 1 and 2 steers primarily reflect the lower feed costs accrued by these groups since both cows and steers were smaller and lighter than the crossbreds and consumed less feed. the higher cost/kg of retail product for BG 1 steers is primarily due to the relatively light carcasses and lower quanity of retail product as compared to the other groups. In the accelerated program, profit calculated using method II was greatest for BG 3 due to their superior retail yield. The advantages in YG in BG 4 were largely overshadowed by the discounts for lower quality grades.

The decreased cost/kg of retail product and the increase in profit with such successive slaughter group may be attributed to the dilution of preweaning costs with increased time on feed.

Among steers from 1978- 1982, BG 2 and BG 4 produced the most profit due to their combination of yield grade and quality grade, while BG 3 cattle were less profitable due to their lower quality grades.

The comparison of costs and profits produced by steers in the accelerated program and by those from previous years reveals an advantage for the accelerated system. Results must be interpreted carefully, however, as the pricing system used favors the leaner cattle produced in the accelerated program. Differences in costs and profits between the two management groups would likely be less dramatic if the 1978 - 1982 steers were evaluated using industry price differentials, since that pricing method places more emphasis on quality grade and relatively less on yield grade.

Conclusions

Greater efficiency of beef production may result from the shorter production cycle and increased feedlot performance associated with an accelerated system. While this project did not include controls during the feedlot phase of the trial, the performance level of these cattle would suggest a slight advantage over a conventional system. Feedlot ADG was generally similar and certainly no worse than commonly reported gains for similar cattle in feedlot situations. In addition, all cattle excelled in feed efficiency, with F:G ratios 15-20% lower than commonly accepted industry values for feedlot cattle. The carcasses produced by the accelerated system, with the exception of those from BG 1, are similar or superior to those of controls in most respects, especially if from SG 1 and SG 2 (Table 23).

A major concern associated with accelerated production systems has been the acceptability of beef produced. Palatability data from this trial are encouraging, and support other findings indicating that beef produced in accelerated systems is acceptable or superior in palatability.

Public concern over the fat and cholesterol content of beef has spawned several recent efforts to identify and manipulate factors related to cholesterol concentrations in muscle. Results of this trial are in general agreement with those of other researchers,

Table 23. COMPARISON OF CARCASSES PRODUCED BY ACCELERATED SYSTEM TO CHOICE QG CONTROL CARCASSES

Item	Accelerated	Control	SE
Fat thickness, cm	1.0	1.2	.06
YG	2.57	2.74	.09
Marbling score[a]	308	427	8.9
QG[b]	11.6	12.8	.12
Carcass fat, %	31.7	33.9	.69
Carcass protein, %	13.1	12.6	.16
Tenderness	6.07	5.8	.14
Overall Satisfaction	6.07	5.9	.11
Muscle Cholesterol, mg/100g raw tissue	71.4	75.2	2.4

[a] 300 = slight, 400 = small 0, etc.

[b] 11 = select^{+}, 12 = choice^{-}, etc.

suggesting that manipulation of cholesterol in beef tissue with management practices is not feasible at this time. The observed increase in muscle cholesterol in SG 3 carcasses cannot be definitively explained. Future research examining cellular cholesterol metabolism or factors related to fatty acid composition of beef seems more appropriate than continued measurement of beef muscle cholesterol concentrations.

Identification of superior breed types for use in accelerated and conventional systems was not unequivocally determined by this trial. Clearly, the unselected Hereford cattle did not respond favorably to accelerated management. No decisive advantages were apparent for the other breed groups, in contrast to reports that larger crossbred cattle out-perform British breed cattle on accelerated systems. However, intense selection has been practiced in BG 2 and 5 for over 20 years, and British breed cattle typical of the industry would likely be intermediate in performance to the unselected Herefords and the selected British breed cattle used in this trial. In addition, the confinement facilities used in this study may have reduced the performance of the crossbred steers. Thus, the similarity of breed type response to accelerated management observed in this study may not be repeatable under industry conditions.

Summary

1. Unselected Hereford steers gained 19% slower than other breed groups when averaged across SG. ADG was similar among the other BG.

2. Contrasts revealed no significant differences in feed conversion between BG.

3. Average daily gain and feed efficiency decreased with time on feed.

4. BG 1 steers produced consistently fatter carcasses with smaller REA than other breed groups, and BG 4 steers produced the leanest carcasses.

5. Cattle in SG 1 and SG 2 failed to produce carcasses with sufficient marbling for the USDA Choice QG.

6. Carcasses in the accelerated system displayed characteristics similar to controls, although controls had slightly higher percentages of carcass fat.

7. No significant differences in any palatability trait were found due to BG or SG. Taste panel scores indicated moderate desirability in all palatability traits.

8. Serum cholesterol concentrations did not differ between weaning and slaughter. BG 1 had the highest serum cholesterol concentration at slaughter.

9. Slaughter serum cholesterol increased with each SG.

10. Muscle cholesterol was not different between breed groups, but was significantly higher for cattle in SG 3.

11. Serum cholesterol was positively correlated with fat thickness and YG. Muscle cholesterol was not significantly correlated to serum cholesterol or to any carcass measure.

12. Cost of production was lower for Hereford (BG 1 and 2) steers. Profit was generally greater for crossbred steers.

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