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# The influence of dietary energy level and biological type on performance and carcass traits of feedlot cattle

William J. Bales

To the Graduate Council:

I am submitting herewith a thesis written by William J. Bales entitled "The influence of dietary energy level and biological type on performance and carcass traits of feedlot cattle." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

E. R. Lidvall, Major Professor

We have read this thesis and recommend its acceptance:

H. Dwight Loveday, W. R. Backus

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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# THE INFLUENCE OF DIETARY ENERGY LEVEL AND BIOLOGICAL TYPE ON PERFORMANCE AND CARCASS TRAITS OF FEEDLOT CATTLE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

William J. Bales

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# ABSTRACT

Data from 144 steer calves of two breed groups, Hereford and Continental (Charolais and Simmental crosses), formed the basis of this study. The steers were purchased through graded feeder calf sales in Tennessee and were considered representative of their respective breed group.

The steers were randomly divided by breed into three frame groups; small, average and large. Within each frame-breed group, animals were randomly assigned to one of three diet groups representing three levels of energy. Treatment one consisted of whole shelled corn supplemented with Tend-R-Leen® fed throughout the study. Treatment two groups were fed corn silage and a concentrate mixture of ground shelled corn and a commercial protein supplement. Steers in treatment three were fed a protein supplemented corn silage until 75% of the predicted slaughter weight had been obtained and then switched to the whole shelled corn and Tend-R-Leen® diet utilized in treatment one.

The steers were weighed and ultrasonically evaluated for 12th rib fat thickness at 14 day intervals until reaching 12 mm of subcutaneous fat at which time they were slaughtered. Days on feed and average daily gain were calculated and the carcass traits of 12th rib fat, ribeye area, internal fat deposition, marbling score, quality grade and yield grade were recorded.

It was found by least squares analysis that breed group influenced (P<.001) final weight and days required to reach the desired compositional endpoint. Cattle of Continental breeding displayed heavier slaughter weights and required more time to reach the 12 mm slaughter point. No differences in average daily gain were found (P>.10) between the two breed groups.

Least squares analysis revealed that variation in dietary energy levels accounted for signifcant variation (P<.01) for both breed groups in the performance traits measured. Increasing the level of energy in the diet resulted in a decrease in final weight and shortened the time required to reach the compositional endpoint, while increasing the average daily gain. Dividing the diet into two stages, as in treatment three, resulted in an increase in days on feed with no advantage in final weight or average daily gain when compared to treatment two.

For the carcass traits measured, least squares analysis reveals breed group affects (P<.05) 12th rib fat, ribeye area and internal fat. Steers of Continental breeding had less subcutaneous fat, larger ribeye areas and greater internal fat deposition than cattle of Hereford type. However, when ribeye area is expressed on a 100 kg carcass weight basis there was no difference (P<.10) found between groups. No differences were found in marbling score, quality grade or yield grade.

Dietary energy levels were revealed through least squares analysis to impact on the carcass traits recorded. Use of the high energy shelled corn ration in treatments one and three resulted in increased ribeye area and more desirable yield grades than treatment two. Increasing the level of energy in the diet also resulted in increased 12th rib fat, decreased internal fat and higher quality grades. Energy level did not influence marbling scores, nor was there a difference noted in ribeye area when compared on an equivalent carcass weight basis.

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# CHAPTER I

## INTRODUCTION

Beef cattle fed for slaughter vary widely in terms of size, shape, breeding, weight and rate of maturity. However, beef packers desire slaughter groups that are relatively homogeneous in their final form, dictating that cattle fall within a prescribed weight range and degree of fatness. There exists a need for the development of feeding and/or management programs that will enable beef cattle producers and feeders to place the highest percentage of their product in the desired market ranges.

At the present time there exists three basic systems for feeding beef cattle; feeding to a compositional endpoint or feeding over a constant number of days on feed or feeding to a constant weight. When beef cattle of various biological types are fed identical diets, individuals will reach a similar composition at widely varying weights. If these cattle are fed over a similar time period, they will vary widely in terms of fatness, weight, carcass composition and quality. Any deviation from these systems must either prove more economical to the producer, or be more effective in producing finished cattle that meet the demands of the packer and the consumer.

In the Southeastern United States, the practice of taking weaned beef cattle and developing them on low energy, forage diets (backgrounding) prior to placing them on high energy diets for fattening is becoming increasingly popular. These programs maximize the use of forage in the production of slaughter beef.

The objectives of this study were:

1. To analyze the effects of varying the level of energy supplied during the growing and finishing phase on growth and composition of feedlot cattle.
2. To study the differences between cattle of differing breeds and/or biological types in their response to diet energy levels and determine if manipulation of the diet energy level can result in a more homogenous final product.
3. To determine if cattle can be accurately identified as to biological type and maturity for placement in a particular feeding and/or management system.

# CHAPTER II

## REVIEW OF LITERATURE

### I. The Effects of Dietary Energy Levels on Growth and Performance

The level of energy in the diet has been cited as one of the principal factors affecting the growth and feedlot performance of the bovine. Rate of gain and efficiency of gain are two of the most important economic traits in feedlot cattle (Klosterman et al., 1976). Rate of true growth involves an increase in muscle tissue, bones and organs and should be distinguished from weight increases due to fat deposition (Maynard and Loosli, 1969). Differences in weight between cattle of similar physical dimensions and age are due to increased fat deposition (Smith et al., 1976; Ferrell et al., 1978; Crouse et al., 1985).

Increases in the level of dietary energy intake results in increases in average daily gains for animals of similar biological type (Jesse et al., 1976; Prior et al., 1977; Bidner et al., 1981; McCarthy et al., 1983). Danner et al. (1980) found no difference in daily gain between steers on a high energy (85% concentrate) and a medium energy (40% concentrate) diet during the growing phase, but gain was increased by increasing concentrate level during the finishing phase ($P<.005$).

Woody et al. (1981) found that in cattle of similar biological type, as the percentage grain increased in the diet the feed required per unit of gain decreased ($P<.005$). This is consistant with the work by Smith et al. (1976) who found that within body type groups, faster gaining cattle were more feed efficient.

Rate at which grain is added to the diet impacts upon efficiency of utilization (Woody et al., 1981). When the diet is divided into a growing and a finishing phase, cattle on a medium energy growing diet and a high energy finishing diet showed improved feed efficiency over cattle fed a high energy diet throughout the feeding period (Fox and Black, 1975). They suggest three factors leading to the improved feed efficiency for the two phase diet. First, positive associative effects are present with feedlot diets when grain makes up 50-80% of the diet. Due to the interactions of the fiber and grain portion of the diet, alterations occur in digestible energy and metabolizable energy, which results in a reduction in the efficiency of energy utilization. Secondly, when switched from a high roughage-low energy diet to a high concentrate-high energy diet there is compensatory performance, with more efficient energy utilization during the finishing phase (Fox et al., 1972). Thirdly, having a faster rate of gain at a heavier weight reduces total maintainence requirement, because the average daily weight maintainence is lower in this system. Woody et al. (1981) showed a 6.5% advantage in feed efficiency when cattle were fed a two-stage diet compared to a constant grain level diet.

## II. The Relationship Between Rate of Gain and Feed Efficiency

Although Kleiber (1961) suggested that feed efficiency is independant of absolute rate of gain, there has been a great deal of research that indicates that as rate of gain increases, feed efficiency is improved, (Klosterman et al., 1976; Lipsey et al., 1978; Loveday et al., 1980). When cattle are fed over a constant time or to a constant weight, the relationship between rate of gain and feed efficiency is increased due to the leaner composition of the weight gained (Klosterman et al., 1976). Smith (1979) determined that the correlation between feed efficiency and rate of gain in the age and weight constant intervals was quite high (r = .94). When cattle are fed to similar subcutaneous fat levels or quality grades, then feed efficiency remains constant across all biological types (Dinus et al., 1976; Prior et al., 1977; Harpster, 1978). McCarthy (1981) cited a trend toward improved feed efficiency for earlier maturing, slower growing cattle fed to a similar compositional endpoint.

## III. The Effects of Dietary Energy Level on Carcass Composition

The effect of nutrition on composition of gain is difficult to address due to the effect maturity and weight have on body composition (Loveday, 1977). Variation in endpoint determination may have the greatest impact on evaluating the role of dietary energy in influencing carcass composition.

Utley et al. (1975) showed that increasing the level of energy in the diet resulted in a 7.5% increase in dressing percentage when cattle were fed to a weight constant endpoint. He further noted increases in 12th rib fat measurements, marbling scores and quality grades. This is in partial agreement with Young and Kauffman (1978) who found that in cattle fed to similar compositional endpoints, increasing the level of energy in the diet resulted in increases in 12th rib fat; kidney, pelvic and heart fat and subsequent yield grades. However, they found no energy effect on marbling score or quality grade. Woody et al. (1981), and Danner et al. (1980) noted a similar trend with an increase in grain in the diet resulting in an increase in subcutaneous fat thickness and dressing percentage, but no effect was seen on marbling score or quality grade. This is contrary to Dinius et al. (1976) who found that as energy in the diet increased, quality grade increased ($P<.01$) for cattle fed to a fat constant endpoint.

Muscle scores have shown little response to energy level although Danner et al. (1980) reported that in cattle of a constant weight, those fed diets higher in energy displayed smaller areas of the longissimus dorsi muscle at the 12th rib separation. This was also noted by Reimer et al. (1975) who found at similar compositional endpoints cattle on high energy diets showed an increase in longissimus area per kilogram of carcass weight, but a smaller longissimus area when compared on a weight constant basis.

Reid et al. (1968) and Jesse et al. (1976) contend that dietary energy levels have no effect on carcass composition. In cattle and lambs fed to a weight constant endpoint, no significant difference was found in subcutaneous fat, quality grade or yield grade between treatments varying in energy levels (Reid et al., 1968). Jesse et al. (1976) found that cattle of similar background on diets varying in energy levels and fed to a weight constant basis displayed no difference in carcass composition. This is in agreement with Craddock et al. (1974) who fed lambs two ration energy levels (4.3 vs 3.8 kcal/g) and found no significant effect on the percentage of fat, protein or moisture when the lambs were slaughtered at 60.0 kilograms.

The rate at which energy is added to the diet may play a role in altering the composition of an animal. Splitting the diet into a low energy growing phase and a high energy finishing phase may become an economic necessity for today's feeding systems (Oltjen et al., 1971). Woody et al. (1981) found that cattle on a low concentrate-high concentrate two phase diet were 6.5% more efficient in protein deposition with an increase in longissimus area and lower yield grade (P<.005). However, this split diet resulted in a decrease in quality grades on a fat constant basis. This was in agreement with earlier work by Wanderstock and Miller (1947) and Oltjen et al. (1971) who found cattle fed split phase diets to have increased ribeye areas and decreased fat thickness.

Ridenour et al. (1982) found that cattle on a high concentrate diet had the advantage in quality grade and longissimus area with no significant difference in fat thickness or yield grade between all concentrate and two phase diets. This was substantiated by Reimer et al. (1975) who found that at a similar compositional end-point, steers fed a split phase diet had an 8-12% advantage in slaughter weight with no significant difference between fat, marbling or yield grade between all concentrate and split phase treatments.

## IV. The Relationship of Growth Rate on Maturity and Performance

It has been suggested that selection for increased rate of gain will result in changes in body type and maturation rate (Berg and Walters, 1983). In order to study different biological types, researchers have utilized the inherent variation in maturation rate among breeds. While early work dealt with comparisons within the British breeds, the importation of the Continental breeds into the United States has resulted in more recent work.

Cole et al. (1963, 1964) using cattle of typical British type, Zebu breeding and dairy type found the larger framed, later maturing Charolais and dairy breeds to gain faster (1.0 kg/day and .98 kg/day respectively) than Hereford cattle (.84 kg/day) when raised under similar production systems. This is in agreement with Dikeman (1973) and Crouse et al. (1985) who found that larger framed, later maturing cattle generally show an advantage in daily gains. Dikeman (1973) further noted that cattle of Angus and Hereford breeding had less potential for growth (muscle) and height when compared to cattle of Simmental and Charolais breeding. Jenkins and Ferrell (1985) noted a similar trend with later maturing, larger framed breeds having greater potential for growth, but this advantage was noted only on high planes of nutrition.

Rate of maturing and biological size are essential factors that influence the ability of an animal to utilize energy. Butts et al. (1980a,b) describes rate of maturity as a fundamental trait of cattle which underlies variation in specific responses such as feed efficiency. The relationship between feed efficiency and biological type or maturation rate varies with the experimental design and endpoint used. Swortzel et al. (1983) reported cattle of different biological types are not necessarily identical at similar ages and weights so neither measure is an appropriate measure of slaughter endpoint. Each biological type has its own optimum endpoint for yield and quality grade.

Cundiff et al. (1981) found that early maturing breed type groups that reached a marbling or compositional endpoint in the fewest days generally required fewer megacalories ME/kg gain. Furthermore, they required less feed per unit of gain than large framed, later maturing breed-type groups ($P<.05$). This is in partial agreement with Ferrell et al. (1978) who showed that smaller type cattle had an advantage in daily gain over large framed cattle on high energy diets due to increased fat deposition when fed over a constant time. Smith et al. (1976) found no difference ($P<.05$) in feed efficiency between Hereford steers and Charolais and Simmental cross steers when fed over a 217 day feeding period. Crouse et al. (1985) found that early maturing Angus steers were more feed efficient to a compositional endpoint than Simmental steers.

When gain is defined as protein growth, larger framed, later maturing cattle have the advantage in feed efficiency (Smith et al., 1977) as they exhibited a leaner composition of gain. Furthermore, Berg and Walters (1983), and Jones et al. (1981) noted that faster growing, leaner breeds are more efficient than slower growing, fatter breeds in converting feed energy to lean tissue. Adams et al. (1973) found that in steers fed to a subjective (low choice) endpoint, larger framed cattle showed a nonsignificant trend for increased daily gains and improved feed efficiency, however, no difference was noted between Hereford cross and Charolais cross steers. Dikeman (1973) cited that larger framed, later maturing cattle gained faster, and faster gaining cattle are generally more efficient in feed utilization due to the dilution of feed maintainence costs. This has been shown in other species as well. Drewry (1980) found that in swine with similar intake levels, the larger framed, later maturing boars had improved feed efficiency, more lean growth and increased daily gains over earlier maturing, conventional boars.

McCarthy et al. (1983) found that large framed cattle had increased daily gains over small framed cattle. Also, the large framed cattle showed greater protein gains with no difference in fat gains ($P<.05$). While the small framed cattle were more efficient energetically, there was no difference in gross energy or feed efficiencies. This was in agreement with Ferrell et al. (1978) who found no difference in feed efficiencies in cattle of various biological types when fed to a constant slaughter date.

## V. The Effects of Breed, Biological Type and Maturity Rate on Carcass Composition

It is well documented throughout the literature that breed and biological type exert a major impact on the partitioning of fat and muscle in the bovine carcass (Cole et al., 1963 and 1964; Charles and Johnson, 1976, Berg et al., 1978a,b and c, and Eversole, 1981). From an economic standpoint, it is important to identify the endpoint when an animal is at its optimum economic efficiency (Berg and Walters, 1983).

Headrick et al. (1970) using reciprocally crossed Hereford, Angus and Charolais heifers found that the larger framed, later maturing Charolais heifers had more lean growth when fed over a constant time basis. The Charolais and Charolais-cross heifers displayed a 7-10% larger longissimus area and heavier carcass weights. Furthermore, these heifers had significantly less 12th rib and internal fat ($P<.05$).

McCarthy et al. (1983), using steers representing large and small biological types, found that when fed to a quality grade endpoint (low choice) the large framed steers had greater longissimus areas, lower 12th rib fat thickness and more desirable yield grades with no difference in U.S.D.A. quality grade. This is consistant with other research (Adams et al., 1973 and Swortzel el al., 1983) that found carcasses from the larger framed, later maturing breeds to have larger ribeye areas and less backfat with no difference in marbling score or quality grade (P>.05) when fed to a similar endpoint.

When fed over a constant feeding period, Charolais and Simmental calves had less 12th rib fat (Koch, 1976) than calves of Hereford breeding. Furthermore, the calves of the large framed breeds had significantly (P<.05) lower yield grades than their Hereford counterparts, while having no difference in quality grades or marbling scores.

The rate at which an animal matures has a dramatic effect on the composition of muscle and adipose tissue during any time period (Berg and Butterfield, 1976).

As the body matures, fat deposition both intramuscular, intermuscular and subcutaneous begins to increase (Berg et al., 1978c). Furthermore, as maturation continues, protein synthesis begins to decrease and muscle cell growth slows (Berg et al., 1978b). Berg et al. (1978a,b,c,) showed that cattle of British type, predominantly Hereford and Angus, were more predisposed to fat deposition at constant ages than cattle of European breeding. In addition, these cattle had less total muscle and a higher fat to muscle ratio than cattle of Continental or European breeding. They therefore concluded that cattle of different breed types at similar ages represent diverse physiological conformations.

This was substantiated by Butterfield and Thompson (1983) using Merino rams. They found that in rams representing two distinct body types, that during serial slaughter those rams representing the small type had consistantly greater proportions of fat. Furthermore, these rams had a lower percentage of muscle (Butterfield et al., 1983). However, when allowed to reach comparable levels of maturity, there was no significant difference between strains for the relationship of muscle and bone, indicating that individuals of similar physiological maturity are compositionally similar when weight differences are accounted for.

## VI. Accuracy and Repeatability of Linear Body Measurements

Various techniques for evaluating linear body measurements and the accuracy and repeatability associated with them have been studied. The most commonly utilized techniques include measurements obtained from life size projections, actual measurements taken from the live animal or a combination of these techniques.

Touchberry and Lush (1950) measured wither height, chest depth, body length and paunch girth of Holstein cattle three times at each of the ages of 6 months, 1, 2, 3, 4, 5 and 7 years. They concluded that a single measurement of each characteristic with the exception of body length is an accurate measurement for use.

Lush and Copeland (1930) obtained 25 different body measurements on Jersey cows and yearling heifers. They reported close general agreement for repeatability in the two groups of cattle, although the error associated with the larger animals was greater. The error associated with obtaining the 25 measurements is comparable with the error associated with live weighing where the standard error was found to be near 1% of the mean weight.

In an effort to compare the accuracy of live animal measurements as compared to photographic measurements, Smith (1950) compared the live animal measurements from 10 cows, 10 calves and 23 yearlings with those taken from life size projections. Estimates from the photographic measurements produced slightly higher estimates of repeatability. Differences in repeatability for the three groups ranged from .546 to .898 for live animal length, .726 to .844 for photographic body length, .784 to .914 for live animal wither height and .807 to .908 for photographic wither height while repeatabilities for live animal and photographic chest depth were similar. Variation due to time of day measured, operator and animal size were nonsignificant.

## VII. The Relationship of Linear Body Measurements, Performance and Carcass Composition

Lush (1928) stated, "In a geometrical sense the animal body is of such complicated shape that any one of a few measurements could approximate a description of it only in the crudest way".

Lush and Copeland (1930) reported that measurements in addition to describing height, length and/or total size involves the law of diminishing returns. The advantage of linear body measurements is that they are objective measures and will remain constant over time, independant of human judgement (Lush, 1928). Black et al. (1938), Guilbert and Gregory (1952) and Lush (1932), summarized and agreed that linear body measurements are useful as a supplement to subjective measures of type.

Research has shown conflicting results in performance and carcass traits of different types of cattle which differ primarily in skeletal dimensions, conformation, and fatness. Black et al. (1938) stated that if ratios of linear body measurements are to be used to predict performance and carcass traits, corrections must be made for fat, weight and age. If different types of cattle are fed to a constant fat composition, performance and carcass trait measures tend to become similar. Much of the conflict may result from the fact that some of the cattle were fed to a more homogeneous fat content while others varied widely in composition.

Linear body measurements when used to describe performance and carcass measurements, fall into two categories: (1) those that increase with fattening more rapidly than weight, such as chest width, heart girth and flank girth, and (2) those that increase with fattening less rapidly than weight, such as head, height and trunk measurements (Hawkins, 1979). These measurements describe fatness either positively or negatively, respectively.

Lush (1928) found that height at the withers and height at the hooks were repeatable and near identical to each other. Kidwell (1955) concluded that height at the hooks was more closely associated with carcass traits than wither height, but found little association with performance. Kohli et al. (1951) found no significant correlation between animal height and feed efficiency.

While there is much agreement that wither height is the best measure of height (Lush, 1932; Black et al., 1938; and Yao et al., 1953); there is little agreement regarding the role it has in estimating performance. Black et al. (1938) found a negative correlation between height at the withers and performance traits. However, Lush (1932) reported greater height at the withers was associated with higher grains based on linear measurements of the steers at weaning.

Cook et al. (1951), Kidwell (1955) and Ternan et al. (1959) found no relationship between length of body and performance traits. Lush (1932) reported a positive association of gains for longer bodied steers. However, negative correlations for body length and average daily gain and feed efficiency, respectively, were reported by Black et al. (1938) and Kohli et al. (1951).

Butts et al. (1980a) using 349 steers representing Angus, Hereford, Angus x Hereford, Charolais and Charolais crosses found wither height, when used in conjunction with breed and subcutaneous fat, to be an accurate predictor for carcass weight and days on feed for cattle consuming high energy diets. He further found depth of body to be negatively correlated with slaughter weight, indicating the deeper bodied cattle were smaller framed, earlier maturing, and displayed lighter slaughter weights.

Lush (1932) and Black et al. (1938) found shallow bodied animals to produce higher yield of edible beef and were more feed efficient than deep bodied steers. Yao et al. (1953) reported that height and length are measures of overall skeletal size and that width, depth and heart girth are measures of thickenss, fleshiness or heaviness.

In relating body measurements with carcass composition, Cook et al. (1951) and Ternan et al. (1959) found significant relationships between certain body measurements and slaughter and carcass quality grade. However, both agreed that the correlations were too low to be of predictive value.

A negative association between wither height and either carcass quality grade, slaughter grade or both of these variables was found in cattle fed to a constant weight or for a constant length of time (Kidwell, 1955; Cook, 1951; Black et al., 1938; Kidwell et al., 1959; and Yao et al., 1953). Being of earlier maturing type, shorter cattle fattened at a faster rate than taller, later maturing cattle.

A nonsignificant relationship between length of body and slaughter grade or carcass quality grade was found by Lush (1928), Cook et al. (1951) and Kidwell (1955). However, Black et al. (1938) and Yao et al. (1953) reported a negative correlation between body length and slaughter and carcass grade. Kidwell et al. (1959) stated that a body measurement or combination of measurements might be found that would reasonably estimate carcass grade.

Montgomery (1978), found a significant ($P<.05$) relationship between the initial height at the withers and initial body length with final weight and carcass weight. He found a negative correlation (-.05) between initial height and carcass quality grade but found no other associations between objective body measurements and carcass traits.

### VIII. Principal Component Analysis as a Means of Describing Size and Shape

Prinicipal component analysis is a technique that recently has been used to help analyze the relationship of body measurements with growth. Carpenter et al. (1971) used three body measurements (chest depth, hook width and body length combined with body height) of 38 Hereford cows to study the priniciple of prinicipal component analysis. General size was the component that accounted for 75% of the generalized variance. A second component seemed to be a contrast of hook width with body length but may also indicate a reflection of condition. However, the first and second components together accounted for 90% of the generalized variance.

Brown et al. (1973b) using Angus and Hereford bulls obtained nine body measurements including, wither height, hip height, shoulder width, pelvic width, loin width, foregirth body depth, flank depth, heart girth and length from shoulder point to pins, as well as weight taken at ages of 4, 8 and 12 months. The prinicple components estimates not only gave a better understanding of the relationship among skeletal dimensions, but also measured differences in size and shape. The first priniciple component at each of the three ages accounted for 56-68% of the variation in all ten measurements with near equal emphasis on all ten standardized traits. The second component indicated at all three ages that tall, narrow bodied and short, wide bodied bulls represented the extremes in shape. Correlations among the second prinicpal components indicated that body shape will remain relatively unchanged.

Brown et al. (1973a) identified more than one shape which was positively associated with efficiency and rate of gain. Bulls that were larger in all measurements at 4 and 8 months grew well on test. Bulls that represented the taller and narrower extreme at similar ages weighed more at the end of the test and gained more weight, but were less feed efficient than the shorter, wider bodied bulls. Several immature shapes were identified that displayed acceptable growth and performance during the test.

### IX. Subjective Analysis as a Means of Describing Cattle

Brown (1956) using studies from Georgia and Arkansas stations found indications that variation among animals accounted for 75 percent or more of the variance in average subjective scores given by a group of competent men at a specific time, but repeated scoring of the same animals by the same men at intervals of several months reduces the animal component of the variance to around 50 percent. Therefore, individuals familiar with evaluation techniques tend to agree on the estimations of an animal at a given time, but most will be influenced to a degree by temporary factors such as age, degree of fatness and muscle conformation.

Gifford et al. (1951) found that evaluators tend to agree most closely on characteristics for which they must consider the entire animal. He found correlations of between .4 and .5 for repeated scoring of the same animal by the same evaluator. Ternan (1959) concluded that a single total score was more useful in describing the general conformation of an animal than a detailed score card utilizing specific traits.

Umberger (1977) found that evaluators agreed most closely on those traits associated with general structural dimensions, such as height and length; were somewhat less consistant in estimating fat; and were inconsistant in evaluating muscle expression. This was in agreement with Hawkins (1979) who utilized feeder calves of varying biological type and breed to determine the correlation between evaluators with varying degrees of expertise.

Gregory et al. (1962) had four evaluators estimate the carcass traits of steers that were from similar and varying management systems.

It was concluded that evaluators are reasonably accurate in predicting group means for carcass traits when the cattle have been under similar treatments, and when the graders are familiar with the feeding and management utilized.

Crouse et al. (1974) using 14 subjective traits of feeder calves found subjective estimates to be useful predictions for growth and performance, but no single trait or group of traits were accurate or repeatable in estimating grading potential of the live animals.

Butts et al. (1980b) found that estimates of body frame i.e., height and length, were highly correlated with final slaughter weight and carcass weight. Subjective estimation of subcutaneous fat was negatively associated with slaughter weight and carcass weight. He further noted there was no significant difference between subjective height evaluation and measured frame for predicting growth parameters. However, ultrasonic evaluation for fat was a slightly more accurate estimation than subjective fat evaluation, although both were useful.

## X. Ultrasonic Techniques for Estimating Subcutaneous Fat Thickness

The use of ultrasonic equipment to estimate the fat and muscle composition of the live animal has become an increasingly important part of compositional research. Watkins et al. (1967), Backus (1968) and McReynolds and Arthaud (1970) have reported substantial accuracy and repeatability in the use of ultrasonic techniques to measure certain body components.

Subcutaneous fat thickness at the 12th rib is of great economic importance to the producer and of scientific value to the researcher, because as the porportion of body fat in the live animal increases, a simultaneous decrease in muscle occurs (Berg and Walters, 1983).

# CHAPTER III

# EXPERIMENTAL PROCEDURE

Data for this study were collected from November 1983, through October 1984, from experiments conducted at the Beef Cattle Feeding Unit of the University of Tennessee Blount Farm, Knoxville, Tennessee.

## I. Experimental Animals

One hundred forty-four steer calves representing Hereford and Hereford type and Continental type (predominantly Simmental and Charolais breeding) were purchased from East Tennessee Feeder Calf sales during the early fall of 1983. Weights ranged from 193.6 to 285.0 kg with an average of 243.1 kg for the Hereford type, and from 212.2 to 307.7 kg for the Continental type with an average of 252.0 kg. Animals were considered to be a respresentative sample of feeder calves of their respective breed, weight and age available in East Tennessee. Three animals were removed due to death loss or illness and eight animals were removed due to the discovery of incomplete castration following onset of the trial.

## II. Allocation System

Upon arrival at the experimental facility, the cattle were allowed to adjust and recover from the stress of weaning and shipment for approximately 3-4 weeks. During this period they were fed corn silage and hay, ad lib, supplemented with grain.

Following the adjustment period, the cattle were weighed, photographed, sonorayed for subcutaneous fat thickness, measured for shoulder width, implanted with Ralgro® and individually identified. They were then subjectively scored by two individuals familiar with livestock evaluation.

The steers were then randomly divided by breed into three frame groups; small, average and large. Within each frame-breed group, animals were randlomly assigned to one of three diet groups of six animals each.

## III. Feeding and Management

Ration treatments represented three levels of energy; high, medium and low. Groups in treatment one were fed a whole shelled corn diet supplemented with 1.1 lbs/hd/day Tend-R-Leen® *ad lib* throughout the experiment. The treatment two groups were fed corn silage, *ad lib*, and a concentrate mixture of ground shelled corn and a commercial protein supplement. This concentrate mixture was fed initially at a rate of 1.25% of body weight (pen mean) daily and increased to 1.40% and 1.55%, when animals reached a pen mean of 8 and 10 mm subcutaneous fat, respectively. The split phase diet groups were fed corn silage, *ad lib*, with a protein supplement to maintain a 12% crude protein level, until approximately 75% of the predicted slaughter weight had been attained (pen mean). Once the 75% predicted weight was attained, the cattle were switched to the whole shelled corn and Tend-R-Leen® diet until slaughter. All diets were fortified with Rumensin® and salt and mineral mixtures were offered free choice throughout the trial.

Animals were weighed and subcutaneous fat measured ultrasonically at 28-day intervals until February 1, and at 14-day intervals thereafter. Second degree polynomial curves were fitted to the fat measurements of individual calves from initiation of the trial to each biweekly measurement date and evaluated to 12 mm of fat. Animals that were projected to reach 13 mm of fat before the next biweekly measurement data were slaughtered on the Friday nearest their predicted date. Carcass data was then obtained the following Monday. Carcass traits recorded were hot carcass weight (carcass weight), adjusted fat thickness, ribeye area, kidney, pelvic and heart fat, marbling score, and carcass quality grade. Days on feed, average daily gain and total gain were also obtained and evaluated.

## IV. Objective Measures

Fat thickness was ultrasonically evaluated, in millimeters, over the longissimus muscle between the 12th and 13th rib three-fourths the distance between the dorsal midline and the distal edge of the longissimus muscle. This process was performed at the onset of the test at 28 day intervals until February 1 and at 14 day intervals thereafter until slaughter.

Shoulder width measurements were obtained using body calipers to measure from point of shoulder to point of shoulder and were recorded in centimeters.

Photographs of each animal were made in a specially designed grid chute. Points of measurement were accomplished by paint branding the steer on the point of the shoulder, ilium and ischium immediately prior to entering the chute. Linear body measurements were obtained from life-size projections of 35 mm transparancies at a later date for the following measurements (Fig. 1):

1. Height at Withers (HW) - from the base of the grid chute to the dorsal top line of the withers.

2. Height at Hip (HH) - from the base of the grid chute to the dorsal top line of the hip.

3. Length of Body (LB) - from the superior point of the shoulders to the posterior ischium.

4. Depth of Body (DB) - from the chest floor, posterior to the forearm, to the shortest distance to the dorsal top line.

## V. Carcass Traits

Carcass traits evaluated were carcass weight; carcass fat thickness over the M. longissimus three-fourths the distance from the midline to the distal edge at the twelfth rib surface; carcass maturity; kidney, pelvic, and heart fat; yield grade; marbling score and quality grade. Yield grade was calculated using procedures outlined by U.S.D.A., (1976); using fat thickness, ribeye area; (hot) carcass weight and kidney, pelvic, and heart fat. Carcass grade and marbling score were determined according to USDA beef grade standards (1976) by a federal grader working in cooperation with an experienced carcass evaluator from The University of Tennessee, Knoxville.

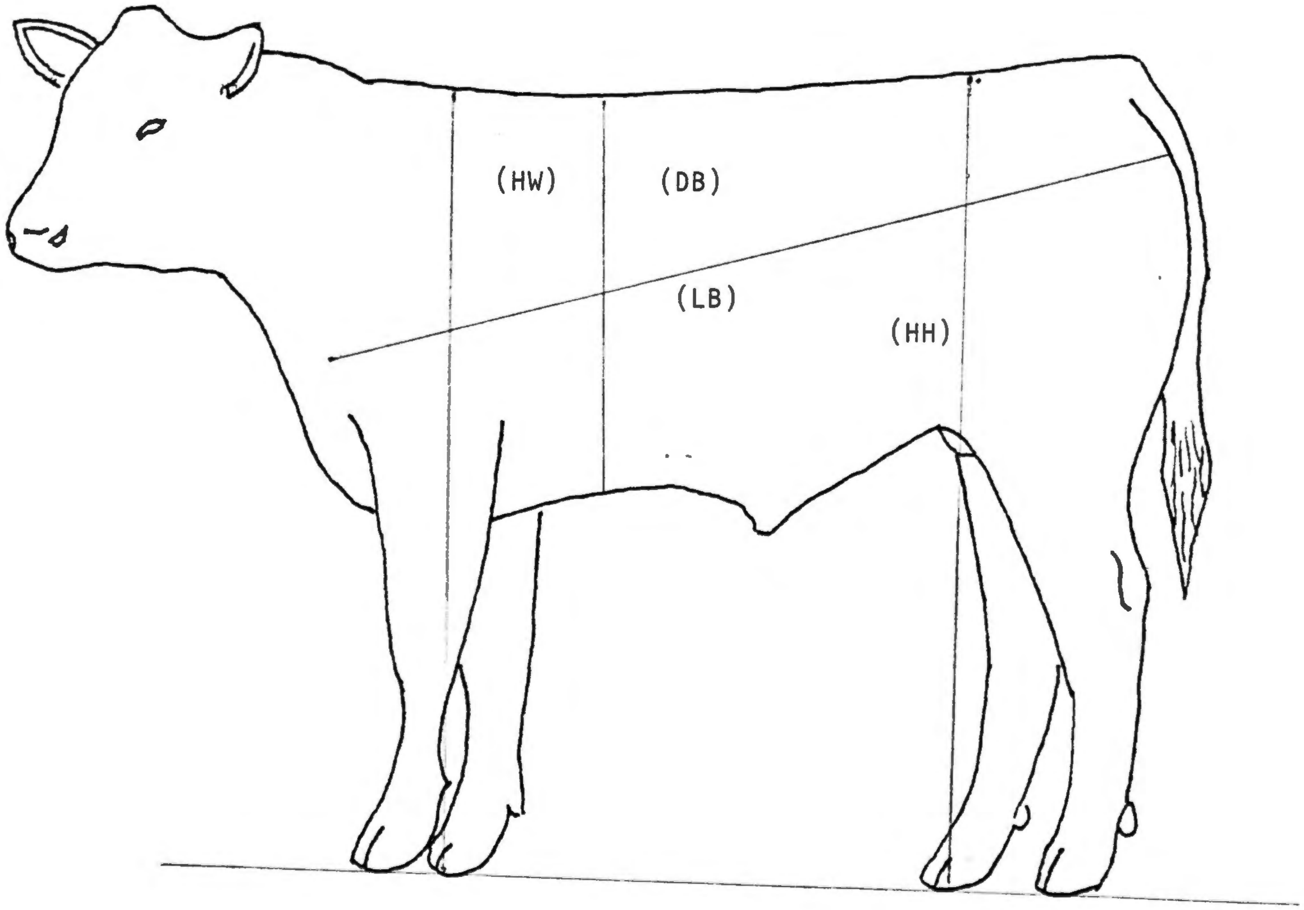


Figure 1. Location of Objective Body Measurements on the Live Steer.

## VI. Subjective Evaluation

Cattle were independently scored by two evaluators. Without the knowledge of the objective measures, height, length, overall frame size, general trimness, head shape, muscle expression and body depth were subjectively scored on a scale of 1 to 5. Each grade was further subdivided into three scores, i.e., 1-, 1°, 1+, 2-, 2°, 2+, etc., resulting in 15 possible scores. For the purpose of analysis and reporting, all scores were transcribed to a 1 to 15 basis, i.e., 1- = 1, 1° = 2, 1+ = 3, etc. A calf appearing to be average in the traits evaluated was given a score of 8. Steers appearing to be smaller in the dimensions being measured were given lower scores relative to the mean, and steers appearing larger in the dimensions evaluated were given higher scores relative to the mean. Evaluators also scored the steers for age, estimated fat thickness and predicted slaughter weight.

### Description of Traits Evaluated

Height was an evaluation of overall tallness of the steer in relation to his weight and/or age. Cattle appearing to be lower set and shorter of cannon were scored from 1 through 7. On the other hand, steers that appeared taller at the hips and withers than average and longer legged were scored from 9 through 15.

Length was an estimation of the overall length of an animal in relation to his weight and/or age. Cattle that appeared shorter bodied with less length from shoulder to pins were scored from 1 through 7, whereas cattle that showed greater length of body were scored from 9 through 15.

Cattle that appeared to be well balanced, symmetrical and proportional in height and length received identical scores for height and length. However, some cattle appeared longer and stretchier than tall, or taller and more upstanding than long. An example of this might result in a 12 score for height and an 8 score for length for an extremely tall, short bodied steer or a score of 6 for height and 9 for length for an extremely short, long bodied steer. Overall frame size was used to account for this variability among the steers, allowing a more exact description of the steers than length or height alone provide. Figure 2 depicts the five frame scores (body types) utilized to describe differences in height, length and overall frame sizes in this study.

In addition to depicting the various body type scores, figure 2 also depicts the weight ranges at which cattle of varying body types would be expected to reach 12 mm of subcutaneous fat at the 12th rib surface. Using this chart as a general guideline, predicted slaughter weight was then estimated in pounds. In addition to overall frame, the evaluator considered overall condition to predict slaughter weight. If an animal appeared to be predisposed to fatness and early maturing or appeared leaner and later maturing the grader would adjust the predicted slaughter weight accordingly.

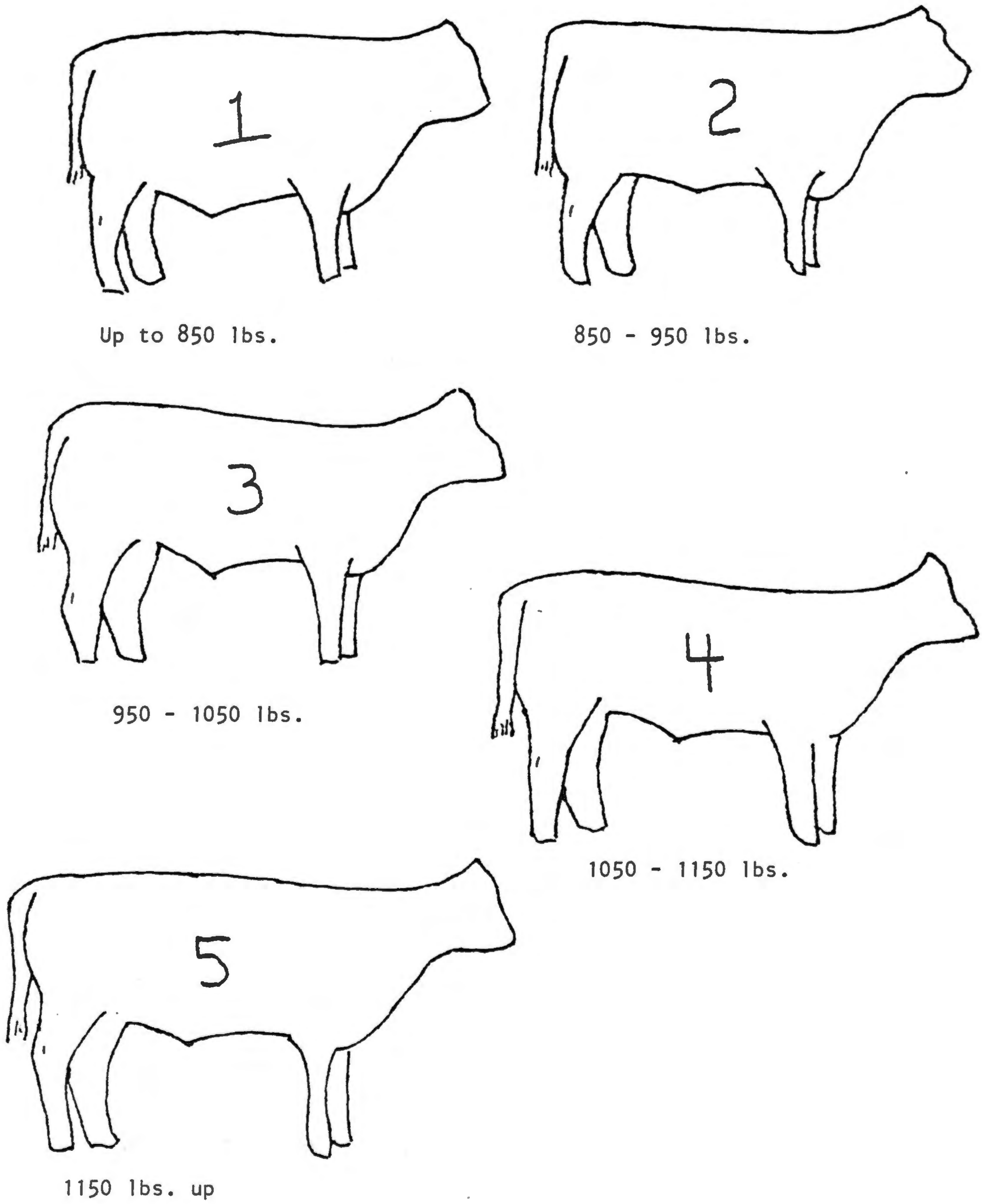


Figure 2. General Appearance of Cattle at Various Frame Scores and the Approximate Weights at Which They Would Be Expected to Have 12 mm of Fat Over the 12th Rib.

General trimness score described the overall "trim" look of a steer as viewed from the side. Steers that were wasty through the brisket, deep middled, and appeared to have a propensity for fat deposition, were scored from 1 through 7. Steers that were cleaner fronted and tighter middled were scored from 9 through 15. This grade was assigned irrespective of 12th rib fat covering.

Head shape was a score describing the general shape and proportion of the head. A head that was moderate in width and slightly longer from the eye to the muzzle than from the eye to the poll was considered to be average. A shorter, broader head was scored from 1 through 7 and a head that was narrower and much longer from eye to muzzle than from eye to poll was scored from 9 through 15.

Muscle expression was a measure of general thickness and body shape. The term "muscle expression" became desirable for use as a result of a study conducted by Butterfield (1970, in Hawkins, 1979) that showed that with fat held constant and bone being a relative constant, muscle mass remained the same when expressed as a percentage of carcass weight when conventional beef cattle were compared against angular, flatter muscled cattle. An angular, flatter muscled steer was therefore scored 1-5, a moderately thick steer scored from 6-10, and a very thick steer scored from 11-15. Factors that influenced muscle expression included thickness and shape of the quarter, prominence or "expression" down the topline, prominence of muscle in the stifle and forearm and width of stance and walk.

Body depth was an estimate of body capacity as viewed from the side. Animals that appeared "shallower" bodied and tighter middled were scored from 1 through 7, while animals that were deeper through the rib and middle were scored from 9 through 15.

Fat was a subjective estimate of fat thickness at the 12th rib location. It was used in conjunction with overall frame to estimate the weight at which each steer would reach the 12 mm external fat slaughter point.

Age was estimated in months. Factors considered when scoring for this trait included a youthful vs. a mature look about the head, length of body, length of tail, substance of bone, foot size and general overall appearance. As cattle mature, their heads appear to coarsen and increase in size in relation to their body, the body lengthens in proportion to height, the feet become larger in relation to the size of the bone and the tail increases in length and exhibits a more prominent switch.

## VII. Statistical Analysis

A generalized linear model was developed to evaluate the effects of breed, treatment, pen, shoulder and hip height and initial weight, along with a breed x treatment and a height x weight interaction in determining performance and carcass traits. Analysis revealed hip height to be a more accurate indicator of frame size than shoulder height, so shoulder height was removed from the final model. In order to analyze the effect of treatment within each group, a second generalized linear model was developed. For those traits or characteristics which displayed a significant breed-treatment interaction, this model allowed the partitioning of treatment effects within each breed group, thereby making analysis of treatment within breed effects possible.

# CHAPTER IV

## RESULTS AND DISCUSSION

This study was designed to evaluate the relationship between biological type and dietary energy levels, and their effect on performance and carcass traits in feedlot cattle. Tables 1-3 contains the means and standard deviations for the carcass and performance traits of the cattle utilized in this study.

### Performance Traits

R-square values (Table 4) show that the models describing finished weight, days on feed and average daily gain account for 63.9, 66.7 and 61.4% of the variation, respectively. Breed and the interaction between breed and treatment had a significant effect ($P<.001$) on both final weight and days on feed. However, breed alone was non-significant ($P>.05$) in explaining differences in average daily gains. Treatment was found to be significant ($P<.001$) for all three traits.

Analysis of the least squares means for breed groups (Table 5) reveals that cattle of the later maturing, larger size had heavier ($P<.001$) finished weights (526 vs. 461 kg) across all treatments. This is consistent with the work of Crouse et al. (1985) who found that larger framed cattle had heavier slaughter weights at a similar compositional endpoint. Furthermore, as previously noted by Smith et al. (1976a), the larger framed cattle required ($P<.05$) more days on feed (307 vs 227) to reach a similar compositional endpoint.

TABLE 1. Means and Standard Deviations of Traits Measured for High Energy Treatments.

| | Hereford Type | | Continental Type | |
|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. |
| Final Weight (kg) | 439.0 | 33.9 | 505.7 | 62.6 |
| Ultrasonic Fat (mm) | 12.45 | 1.14 | 12.26 | 1.00 |
| Days on Feed | 179.7 | 4.1 | 221.2 | 58.4 |
| Average Daily Gain (kg/day) | 1.11 | .12 | 1.14 | .11 |
| Total Gain (kg) | 199.4 | 22.6 | 249.9 | 57.1 |
| Carcass Weight (kg) | 279.4 | 23.0 | 319.3 | 33.9 |
| Carcass Fat | 15.5 | 4.8 | 11.6 | 3.0 |
| Rib-eye Area (sq. cm) | | | | |
| Marbling Score[1] | 4.57 | .64 | 4.66 | .72 |
| Quality Grade[2] | 11.9 | .79 | 12.0 | .90 |
| Kidney, pelvic and heart fat (%) | 2.0 | .48 | 2.1 | .42 |
| Yield Grade | 3.2 | .75 | 2.8 | .56 |

[1]Marbling score - 3=slight, 4=small, 5=modest, 6-moderate

[2]Quality grade - 9=low good, 10=average good, 11=high good, 12=low choice, 13=average choice, 14=high choice

TABLE 2. Means and Standard Deviations of Traits Measured for Medium Energy Treatments.

| | Hereford Type | | Continental Type | |
|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. |
| Final Weight (kg) | 435.2 | 32.1 | 553.5 | 56.4 |
| Ultrasonic Fat (mm) | 11.87 | 1.14 | 11.85 | .65 |
| Days on Feed | 215.7 | 27.9 | 335.7 | 84.1 |
| Average Daily Gain (kg/day) | .88 | .08 | .87 | .16 |
| Total Gain (kg) | 188.7 | 28.4 | 301.5 | 62.9 |
| Carcass Weight (kg) | 258.0 | 23.8 | 316.4 | 23.5 |
| Carcass Fat (mm) | 11.5 | 1.9 | 11.4 | 3.0 |
| Rib-eye Area (sq. cm) | 69.32 | 5.24 | 74.84 | 6.50 |
| Marbling Score[1] | 4.12 | .78 | 4.54 | .55 |
| Quality Grade[2] | 11.0 | 1.15 | 11.6 | 1.00 |
| Kidney, pelvic and heart fat (%) | 1.9 | .48 | 2.6 | .50 |
| Yield Grade | 2.7 | .38 | 3.1 | .56 |

[1]Marbling score - 3=slight, 4=small, 5=modest, 6-moderate

[2]Quality grade - 9=low good, 10=average good, 11=high good, 12=low choice, 13=average choice, 14=high choice

TABLE 3. Means and Standard Deviations of Traits Measured for Split Phase Diets.

| | Hereford Type | | Continental Type | |
|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. |
| Final Weight (kg) | 452.6 | 46.3 | 575.6 | 77.6 |
| Ultrasonic Fat (mm) | 12.09 | .61 | 11.54 | 1.31 |
| Days on Feed | 256.7 | 39.5 | 373.5 | 73.3 |
| Average Daily Gain (kg/day) | .82 | .12 | .88 | .08 |
| Total Gain (kg) | 209.6 | 47.3 | 327.2 | 71.7 |
| Carcass Weight (kg) | 268.0 | 30.4 | 319.8 | 35.8 |
| Carcass Fat (mm) | 12.0 | 2.1 | 9.5 | 3.6 |
| Rib-eye Area (sq. cm) | 69.71 | 7.59 | 82.26 | 8.91 |
| Marbling Score[1] | 4.10 | .78 | 4.60 | .81 |
| Quality Grade[2] | 11.0 | 1.1 | 11.7 | 1.0 |
| Kidney, pelvic and heart fat (%) | 1.9 | .48 | 2.5 | .54 |
| Yield Grade | 2.7 | .38 | 2.6 | .72 |

[1]Marbling score - 3=slight, 4=small, 5=modest, 6-moderate

[2]Quality grade - 9=low good, 10=average good, 11=high good, 12=low choice, 13=average choice, 14=high choice

TABLE 4. Analysis of Variance for Final Weight, Days on Feed and Average Daily Gain.

| Source | Final weight df | Final weight MS[1] | Days on feed df | Days on feed MS[1] | Average daily gain df | Average daily gain MS[1] |
|---|---|---|---|---|---|---|
| Breed | 1 | 397883.95* | 1 | 125070.76* | 1 | 0.0157 |
| Treatment | 2 | 209929.62* | 2 | 308686.15* | 2 | 9.2081* |
| Breed x Treatment | 2 | 165407.18* | 2 | 57895.25* | 2 | 0.2162 |
| Pen | 1 | 13200.81 | 1 | 1855.95 | 1 | 0.3031 |
| Hip height | 1 | 25724.05 | 1 | 866.99 | 1 | 0.1066 |
| Initial weight | 1 | 12133.31 | 1 | 57.62 | 1 | 0.0499 |
| Height x weight | 1 | 9972.35 | 1 | 133.88 | 1 | 0.0583 |
| Residual | 125 | 11045.08 | 125 | 1106305.30 | 125 | 7.0448 |
| R-square | .64 | | .67 | | .61 | |

[1]Mean squares for treatment effects are Type III sums of squares.

*P<.001

Variation in dietary energy levels accounted for significant differences in the performance traits measured for both breed groups. Table 6 lists the least squares means and standard errors for the performance traits for each ration treatment group. As energy levels in the diet were increased, there was a resulting decrease noted in final weight (469.1, 499.5, and 512.6 kg, respectively for treatments 1, 2, and 3). Consequently, as diet energy decreased, there was a corresponding increase noted in days on feed required to reach the same compositional endpoint (200, 290, and 312 for treatments 1, 2 and 3, respectively). In addition, differences in average daily gain favored those cattle on the higher energy diets (1.12, .88 and .84 kg/day for treatments 1, 2 and 3, respectively).

A more accurate measure of the differences observed is obtained by examining the interaction of breed and treatment in this study. Tables 7 and 8 show the least squares means for each of the performance traits measured for the respective breed x treatment groups. For steers of Hereford breeding and type (Table 7), there was no significant ($P>.05$) treatment effect on final weight. This indicates that reducing the energy level during the early growth phase to increase the slaughter weight at a similar compositional endpoint was ineffective in cattle of this biological type when fed and managed under similar conditions. There was, however, a significant treatment effect ($P<.001$) observed in the number of days required to reach the desired compositional endpoint. As the level of energy in the diet was increased, a resulting decrease ($P<.05$) in days on feed

TABLE 5. Least Squares Means and Standard Error for Final Weight, Days on Feed and Average Daily Gain by Biological Type (Breed) Groups.

| | Hereford Type | | Charolais Type | |
|---|---|---|---|---|
| Trait | Mean | SE | Mean | SE |
| Final weight | $461.1^{a}$ | 6.9 | $526.0^{b}$ | 6.8 |
| Days on feed | $227.0^{a}$ | 7.7 | $307.4^{b}$ | 7.7 |
| Average daily gain (kg/day) | .95 | .015 | .94 | .015 |

$^{a,b}$Means in the same row that do not have a common subscript differ (P<.001).

TABLE 6. Least Squares Means and Standard Error for Final Weight, Days on Feed and Average Daily Gain by Diet Groups.

| Trait | High energy diet Mean | SE | Medium energy diet Mean | SE | Split phase diet Mean | SE |
|---|---|---|---|---|---|---|
| Final weight (kg) | $469.1^{a}$ | 7.2 | $499.5^{b}$ | 7.3 | $512.6^{b}$ | 7.2 |
| Days on feed | $200.0^{a}$ | 8.2 | $290.0^{b,i}$ | 8.3 | $312.0^{b,j}$ | 8.1 |
| Average daily gain (kg/day) | $1.12^{a}$ | 0.016 | $.88^{b}$ | 0.017 | $.84^{b}$ | 0.016 |

$^{a,b}$Means in the same row that do not have a common subscript differ (P<.001).

$^{i,j}$Means in the same row that do not have a common subscript differ (P<.01).

occured, with those cattle fed the high energy diet requiring the fewest days (178) to reach the compositional endpoint. A correlated difference in average daily gain (A.D.G.) was also noted as the cattle on the high energy diets showed the greatest gains ($P<.001$), while those on the medium energy diet gained faster than those on the split phase diet ($P<.05$).

For those cattle of Continental type, the variation between treatments was somewhat different (Table 8). Cattle of the larger biological type displayed a significant response ($P<.001$) to the high energy diet, reaching the compositional endpoint at a lighter weight. There was no difference ($P>.05$) noted in final weight between the medium and low energy diets. The effect of dietary energy on days required to reach the desired compositional endpoint followed a similar pattern, with those cattle receiving the high energy diet requiring the fewest days to reach the 12 mm slaughter endpoint ($P<.001$). Again, no separable difference ($P>.05$) was noted between the medium and low energy treatment groups. The same trend emerged for the treatment influence on average daily gains. Those cattle on the high energy diet produced the greatest daily gains (P.<001), while the split phase diet showed a non-significant ($P>.05$) advantage (.881 vs .872 kg/d) in daily gains over the medium energy treatment groups. This indicates that splitting the diet into a growing and finishing phase would be justifiable only when costs of high energy grains make grain diets economically unfeasable.

TABLE 7. Least Squares Means and Standard Errors for Final Weight, Days on Feed and Average Daily Gain for Treatment Groups Within Hereford Type Cattle.

| | Treatment 1 | | Treatment 2 | | Treatment 3 | |
|---|---|---|---|---|---|---|
| Trait | Mean | SE | Mean | SE | Mean | SE |
| Final weight (kg) | 440.1 | 6.8 | 438.0 | 7.0 | 448.6 | 7.1 |
| Days on feed | $178.1^{a}$ | 5.6 | $219.0^{b}$ | 5.7 | $254.9^{c}$ | 5.8 |
| Average daily gain (kg/day) | $1.10^{a}$ | 0.02 | $0.89^{b,i}$ | 0.02 | $0.81^{b,j}$ | 0.02 |

$^{a,b}$Means in the same row that do not have a common subscript differ ($P<.001$).

$^{i,j}$Means in the same row that do not have a common subscript differ ($P<.05$).

TABLE 8. Least Squares Means and Standard Errors for Final Weight, Days on Feed and Average Daily Gain by Treatment Groups Within Continental Type Cattle.

| Trait | Treatment 1 | | Treatment 2 | | Treatment 3 | |
|---|---|---|---|---|---|---|
| | Mean | SE | Mean | SE | Mean | SE |
| Final weight (kg) | $498.1^{a}$ | 12.7 | $557.0^{b}$ | 13.3 | $579.8^{b}$ | 12.4 |
| Days on feed | $221.9^{a}$ | 15.2 | $358.0^{b}$ | 15.9 | $370.8^{b}$ | 14.8 |
| Average daily gain (kg/day) | $1.13^{a}$ | 0.023 | $0.87^{b}$ | 0.024 | $0.88^{b}$ | 0.022 |

$^{a,b}$Means in the same row that do not have a common subscript differ (P<.001).

Carcass Traits

Due to severe parasite infestation (grubs), ten steers were deleted from the carcass trait analysis. The results and discussion of variation in carcass traits are from actual measurements of one hundred twenty-five beef carcasses utilized in this study.

Analysis of the R-square value (Table 9) reveals that the model, utilized to evaluate treatment effects on carcass fat, explains 29.3% of the variation between both breed groups in measured carcass fat. Breed was found to have a significant effect (P<.05) on the amount of 12th rib fat found on the carcasses (Table 9). Hereford cattle displayed (Table 10) greater 12th rib fat measurements (P<.01) than cattle of Continental breeding (12.0 vs 10.6 mm). No differences (P>.05) were noted in fatness between treatment groups or among individual breed-treatment groups. This was to be expected as all cattle were slaughtered at a similar measured fat thickness. The difference between the fat measurements of cattle varying in biological type was in agreement with Adams et al. (1973) who found in cattle fed to a similar quality grade endpoint the larger framed, later maturing types tended to show decreased carcass fat measurements.

Table 9 reveals the model was effective in describing variation in ribeye area in this study, as it explained 40.8% of the variation among the breed-treatment groups. Differences between the two breed groups was highly significant (P<.001) as those cattle representing the larger biological type consistantly displayed larger ribeye

TABLE 9. Analysis of Variance for 12th Rib Fat; Ribeye Area; Marbling Score; Kidney, Pelvic and Heart Fat; Quality Grade and Yield Grade.

| | 12th rib fat | | Ribeye area | | Marbling score | | KPH | | Quality grade | | Yield grade | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Source | df | MS | df | MS | df | MS | df | MS | df | MS | df | MS |
| Breed | 1 | 34.85* | 1 | 22.83*** | 1 | 0.01 | 1 | 2.15** | 1 | 0.004 | 1 | 0.25 |
| Treatment | 2 | 28.12 | 2 | 12.26** | 2 | 1.07 | 2 | 1.14 | 2 | 9.63* | 2 | 1.05 |
| Breed x Treat. | 2 | 31.97 | 2 | 10.39 | 2 | 0.99 | 2 | 2.59** | 2 | 2.23 | 2 | 2.52* |
| Residual | 124 | 847.4 | 124 | 228.2 | 124 | 66.55 | 124 | 39.3 | 124 | 145.3 | 124 | 36.7 |
| R-square | .29 | | .41 | | .14 | | .24 | | .22 | | .14 | |

[1]Nonsignificant model effects are not shown.

*P<.05

**P<.01

***P<.001

TABLE 10. Least Squares Means and Standard Errors for 12th Rib Fat; Ribeye Area; Ribeye Area per 100 kg Carcass Weight; Marbling Score; Kidney, Pelvic and Heart Fat; Quality Grade; and Yield Grade by Biological Type (Breed) Group.

| Trait | Hereford Type | | Continental Type | |
|---|---|---|---|---|
| | Mean | SE | Mean | SE |
| 12th rib fat (mm) | $12.0^{i}$ | .36 | $10.6^{j}$ | .34 |
| Ribeye area (sq. cm) | $70.3^{x}$ | .86 | $78.9^{y}$ | .97 |
| Ribeye area per 100 kg carcass weight (sq. cm) | 26.3 | .32 | 24.9 | .32 |
| Marbling score[1] | 4.4 | .11 | 4.5 | .10 |
| Kidney, pelvic and heart (%) | $2.01^{i}$ | .08 | $2.36^{j}$ | .07 |
| Quality grade[2] | 11.7 | .15 | 11.7 | .14 |
| Yield grade | 2.85 | .08 | 2.73 | .08 |

[1]Marbling score - 3=slight, 4=small, 5=modest, 6=moderate

[2]Quality grade - 9=low good, 10=average good, 11=high good, 12=low choice, 13=average choice, 14=high choice.

$^{a,b}$Means in the same row without a common subscript differ ($P<.05$).

$^{i,j}$Means in the same row without a common subscript differ ($P<.01$).

$^{x,y}$Means in the same row without a common subscript differ ($P<.001$).

areas across all treatments (Table 10). This effect was expected, as a greater percentage of growth in the later maturing cattle occurs in muscle tissue growth. It is well documented by Headrick et al. (1970) and Adams et al. (1973), that during feeding either over time or to a constant endpoint, cattle of larger biological type express more of their growth in the muscle tissues.

Treatment effects were found to be significant (P<.01); yet, did not show the results found in the review of previous research. Cattle fed the low energy diet produced the greatest longissumus dorsi area (Table 11); however, it was not significantly different from longissimus areas of the cattle on the high energy diet (P<.05). Those cattle on the medium energy diet had the smallest longissimus areas of the three treatment groups (P<.01). This is in contrast to work by Wanderstock and Miller (1947), and Danner et al. (1980), who found increasing the level of energy in the diet resulted in smaller ribeye areas in cattle fed to a grade constant basis. Furthermore, the above work has documented that increasing the time required to reach a selected endpoint results in increases in the major muscle tissues. Since final weight, fat and days on feed were similar for the medium energy and split phase treatment groups (P<.05), it seems the variation noted is due primarily to genetic factors rather than environmental or management factors.

Upon examination of individual breed-treatment groups (Tables 12 and 13) it should be noted the variation between treatment groups

TABLE 11. Least Squares Means and Standard Errors for 12th Rib Fat; Ribeye Area; Marbling Score; Kidney, Pelvic and Heart Fat; Quality Grade and Yield Grade by Treatment Group.

| | High energy | | Medium energy | | Split phase | |
|---|---|---|---|---|---|---|
| | Mean | SE | Mean | SE | Mean | SE |
| 12th rib fat (mm) | $11.9^{a}$ | .40 | $11.2^{b}$ | .37 | $10.7^{b}$ | .36 |
| Ribyeye area (sq. cm) | $75.2^{a}$ | 1.03 | $72.2^{b}$ | 1.05 | $76.3^{a}$ | 1.02 |
| Ribeye area per 100 kg carcass weight (sq. cm) | 25.3 | .38 | 25.5 | .41 | 26.0 | .43 |
| Marbling score[1] | 4.6 | .12 | 4.3 | .11 | 4.4 | .11 |
| KPH (%) | $2.04^{a}$ | .09 | $2.25^{b}$ | .08 | $2.26^{b}$ | .08 |
| Quality grade[2] | $12.1^{a}$ | .17 | $11.3^{b}$ | .15 | $11.6^{b}$ | .15 |
| Yield grade | $2.77^{a}$ | .09 | $2.92^{b}$ | .08 | $2.69^{a}$ | .08 |

[1]Marbling score - 3=slight, 4=small, 5=modest, 6=moderate.

[2]Quality grade - 9=low good, 10=average good, 11=high good, 12=low choice, 13=average choice, 14=high choice.

[a,b]Means in the same row without a common subscript differ (P 05).

[i,j]Means in the same row without a common subscript differ (P 01).

[x,y]Means in the same row without a common subscript differ (P 001).

is found only in the larger type cattle. While a similar trend was noted in the Hereford type cattle, it was found to be non-significant (P>.05) across all treatments. However, significant variation (P<.05) existed between each of the three treatment groups for the Continental type with the split phase diet group displaying the largest longissimus areas, followed by the high energy diet group. The difference noted in the medium energy diet may partially be explained by the increased carcass fat found in this treatment, but is more likely due to inherent genetic variation.

While variation in longissimus area exists within breed and treatment groups, when groups are compared on an equivalent carcass weight basis (longissimus area per 100 kg of hot carcass weight) there are no differences (P>.10) in longissimus area (Tables 10 and 11). The trend is for the smaller type cattle to have greater longissimus areas per 100 kg of hot carcass weight; however, the trend is nonsignificant (P>.10). This is in agreement with Jesse et al. (1976) who found cattle fed to a similar slaughter endpoint displayed no difference (P>.10) in muscle growth, when expressed on a carcass equivalent basis. Tables 11 and 13 reveal that alteration of the energy level supplied during the growing and finishing has no effect (P>.10) on muscle growth. The trend noted for increased muscle area for the split phase diet, particularly in the Continental types, is consistant with work by Woody et al. (1981) who showed nonsignificant (P>.10) increase in muscle area for cattle fed a two stage diet. However, Reid et al. (1968) found no diet energy effect on muscle

TABLE 12. Least Squares Means and Standard Errors for 12th Rib Fat; Ribeye Area; Ribeye Area per 100 kg Carcass Weight; Marbling Score; Kidney, Pelvic and Heart Fat; Quality Grade; and Yield Grade by Treatment Group for Cattle of Hereford Type.

| Trait | High energy Mean | High energy SE | Medium energy Mean | Medium energy SE | Split phase Mean | Split phase SE |
|---|---|---|---|---|---|---|
| Carcass fat (mm) | 12.6 | .52 | 11.6 | .44 | 12.0 | .44 |
| Ribeye area (sq. cm) | 72.0 | 1.7 | 69.3 | 1.1 | 70.0 | 1.5 |
| Ribeye area per 100 kg carcass weight (sq. cm) | 25.8 | .57 | 27.0 | .48 | 26.2 | .60 |
| Marbling score[1] | $4.7^{a}$ | .20 | $4.1^{b}$ | .17 | $4.3^{b}$ | .17 |
| Kidney, pelvic and heart fat (%) | 2.03 | .14 | 1.90 | .11 | 1.99 | .11 |
| Quality grade[2] | $12.1^{i}$ | .27 | $10.9^{j}$ | .23 | $11.5^{j}$ | .23 |
| Yield grade | 2.8 | .11 | 2.8 | .09 | 2.8 | .09 |

[1]Marbling score - 3=slight, 4=small, 5=modest, 6=moderate.

[2]Quality grade - 9=low good, 10=average good, 11=high good, 12=low choice, 13=average choice, 14=high choice.

[a,b]Means in the same row without a common subscript differ (P<.05).

[i,j]Means in the same row without a common subscript differ (P<.01).

growth at a constant carcass weight. Cattle of Hereford type (Table 12) displayed a similar trend with longissimus area remaining constant (P>.05) across all treatments.

As might be expected in cattle fed to a compositional endpoint, there was no differences (P>.05) found between breed and treatment groups in marbling scores (Table 9). This is in agreement with Loveday (1977) and Adams et al. (1973) who found marbling scores to be associated with external fat covering. When the model was partitioned into individual breed-treatment groups, no variation (P>.05) was found among groups with the exception of Hereford type steers on the high energy diets that displayed greater marbling scores (P<.05). Since this group also displayed the greatest 12th rib fat measurements, it strengthens the theory that there is a positive association between 12th rib fat and marbling scores.

Analysis of the R-square value (Table 9) shows that the model explained 24.0% of the variation in kidney, pelvic and heart fat among the steer groups. Breed was found to have the greatest influence on internal fat measurements (P<.01), with Hereford steers having less internal fat than the larger Continental type steers (Table 10). This is completely opposite to the findings of Cole et al. (1964) who found smaller framed cattle of British breeding displayed greater propensity for internal fat deposition than cattle of the larger framed, later maturing breeds. While some authors have shown nonsignificant trends in this direction, recent work has not shown the magnitude of the trends observed and may indicate that greater sample sizes would be necessary to substantiate these findings.

When the model is partitioned to examine breed x treatment effects on internal fat in both the Hereford and Continental type, those cattle on the high energy diet were different from either the medium energy or split phase groups (Tables 12 and 13). For cattle of Hereford breeding, those fed the high energy diet showed a trend (Table 12) for greater internal fat but the difference was nonsignificant (P>.10). However, for steers of Charolais breeding, those fed the high energy diet had the least internal fat (P<.001), and no difference between the lower diet energy levels (P>.10). Since carcass fat has already been shown to be highest in the high energy groups, this might indicate a relationship between maturity and internal fat deposition.

Table 9 shows that the model used to describe variation in quality grade explains 21.6% of the differences between the breed and treatment groups used in this study. There was no difference (P>.10) found between the two breed groups for quality grade; however, this was anticipated as the cattle were slaughtered at similar compositional endpoints. Both breed groups averaged high good at slaughter according to United States Department of Agriculture Grading Standards for Beef.

Across both breed groups, cattle fed the high energy diets had the highest quality grades reaching an average of low choice (P<.01).

TABLE 13. Least Squares Means and Standard Errors for Carcass Fat; Ribeye Area; Ribeye Area per 100 kg Carcass Weight; Marbling Score; Kidney, Pelvic and Heart Fat; Quality Grade; and Yield Grade by Treatment Group for Cattle of Charolais Type.

| Trait | High energy | | Medium energy | | Split phase | |
|---|---|---|---|---|---|---|
| | Mean | SE | Mean | SE | Mean | SE |
| Carcass fat (mm) | 11.2 | .57 | 10.8 | .60 | 9.4 | .56 |
| Ribeye area (sq. cm) | 78.9 | 1.4 | 75.4$^{j}$ | 1.4 | 82.3$^{i}$ | 1.8 |
| Ribeye area per 100 kg carcass weight (sq. cm) | 24.9 | .49 | 23.8 | .45 | 25.9 | .62 |
| Marbling score[1] | 4.5 | .15 | 4.5 | .15 | 4.6 | .14 |
| Kidney, pelvic and heart fat (%) | 2.05$^{x}$ | .11 | 2.59$^{y}$ | .11 | 2.53$^{y}$ | .10 |
| Quality grade[2] | 12.0 | .21 | 11.6 | .22 | 11.7 | .20 |
| Yield grade | 2.7$^{a}$ | .13 | 3.0$^{b}$ | .14 | 2.6$^{a}$ | .13 |

[1]Marbling score - 3=slight, 4=small, 5=modest, 6=moderate.

[2]Quality grade - 9=low good, 10=average good, 11=high good, 12=low choice, 13=average choice, 14=high choice.

$^{a,b}$Means in the same row without a common subscript differ ($P<.05$).

$^{i,j}$Means in the same row without a common subscript differ ($P<.01$).

$^{x,y}$Means in the same row without a common subscript differ ($P<.001$).

This was in agreement with Dinius et al. (1976), Utley et al. (1975) and Wanderstock and Miller (1947) who found that increasing the level of energy in the diet results in a corresponding increase in quality grades for cattle fed to a grade or weight constant endpoint. No difference was noted between the split phase and medium energy diets (P>.10), although a trend was noted for higher quality grades in the split phase energy diet (Table 11). This may be attributed to the high energy finishing diet fed immediately prior to slaughter. When the model was partitioned into breed-treatment groups the same pattern emerged; however, it was found to be significant (P<.01) only in the Hereford steers (Table 12) with those steers on the high energy diet having higher quality grades than either of the lower energy diets.

Analysis of Table 9 reveals that only 13.8% of the variation in yield grade was explained by the model. Breed effects were non-significant (P>.10), although the cattle of Charolais breeding possessed slightly more desirable yield grades than cattle of Hereford breeding and type (Table 10). This agrees with the findings of Dinius et al. (1976) who found that in cattle fed to a fat constant endpoint, smaller framed cattle had less desirable yield grades than later maturing cattle. Overall treatment effects were found to be nonsignificant (P>.10), although it was noted the more desirable yield grades were in the low and high energy diet groups compared to the medium energy diet groups (Table 11). This agrees with work by Woody et al.(1981) who found cattle fed a low energy diet during the growing phase to possess more desirable yield grades at slaughter. However, this contrasts with work by Young and Kaufman (1978) and Utley et al.(1975) who found that increasing the dietary energy level resulted in less desirable yield grades. Part of this discrepency may be explained by the termination point utilized, as much of the early work in breed-energy effects utilized subjective quality grade or fat estimations to determine optimum slaughter points.

Upon partitioning the data into breed x treatment groups, no differences (P>.10) in final yield grade were found between treatments for cattle of Hereford breeding and type (Table 12). For cattle of Charolais type, however, steers fed the low energy diet had the most desirable yield grades (Table 13) while those on the medium energy diet had the least desirable grades (P<.05). While these trends generally follow previous work, the large variation in the medium energy diet has not been previously cited in similar studies. It may later become apparent that the metabolizable energy available in this diet was insufficient for optimum muscle growth, resulting in less desirable yield grades for these larger framed cattle on this diet.

## Conclusions

Results of this study led to the following conclusions:

1. Cattle representing diverse biological types and maturity patterns varied widely in regard to weight, physical dimensions and carcass composition when fed to a fat constant equivalent. Cattle of the larger, later maturing type displayed heavier finished and carcass weights, greater skeletal measurements and a greater muscle to fat ratio when compared to cattle of the smaller framed, earlier maturing types when slaughtered at a similar fat endpoint.
2. The utilization of corn silage during the growing phase to increase final weight was ineffective in the earlier maturing cattle. Furthermore, its use did not result in changes in the carcass traits for this breed group. Therefore, its use in a feeding system should be weighed strictly on the economic advantages such a system might present.
3. For the larger type steers the use of corn silage as a low energy growing ration resulted in increased slaughter weights, but had little affect on carcass traits. Its use resulted in cattle considered to be relatively large for current industry needs.
4. For cattle of both biological types, the use of a high energy corn diet for the entire feeding period proved to be the most ideal diet under the management system utilized.

# CHAPTER V

## SUMMARY

Data from 144 steer calves of two breed groups, Hereford and Continental (Charolais and Simmental crosses), formed the basis of this study. The steers were purchased through graded feeder calf sales in Tennessee and were considered representative of their respective breed group.

The steers were randomly divided by breed into three frame groups; small, average and large. Within each frame-breed group, animals were randomly assigned to one of three diet groups representing three levels of energy. Treatment one consisted of whole shelled corn supplemented with Tend-R-Leen® fed throughout the study. Treatment two groups were fed corn silage and a concentrate mixture of ground shelled corn and a commercial protein supplement. Steers in treatment three were fed a protein supplemented corn silage until 75% of the predicted slaughter weight had been obtained and then switched to the whole shelled corn and Tend-R-Leen® diet utilized in treatment one.

The steers were weighed and ultrasonically evaluated for 12th rib fat thickness at 14 day intervals until reaching 12 mm of subcutaneous fat at which time they were slaughtered. Days on feed and average daily gain were calculated and the carcass traits of 12th rib fat, ribeye area, internal fat deposition, marbling score, quality grade and yield grade were recorded.

It was found by least squares analysis that breed group influenced (P<.001) final weight and days required to reach the desired compositional endpoint. Cattle of Continental breeding displayed heavier slaughter weights and required more time to reach the 12 mm slaughter point. No differences in average daily gain were found (P>.10) between the two breed groups.

Least squares analysis revealed that variation in dietary energy levels accounted for signifcant variation (P<.01) for both breed groups in the performance traits measured. Increasing the level of energy in the diet resulted in a decrease in final weight and shortened the time required to reach the compositional endpoint, while increasing the average daily gain. Dividing the diet into two stages, as in treatment three, resulted in an increase in days on feed with no advantage in final weight or average daily gain when compared to treatment two.

For the carcass traits measured, least squares analysis reveals breed group affects (P<.05) 12th rib fat, ribeye area and internal fat. Steers of Continental breeding had less subcutaneous fat, larger ribeye areas and greater internal fat deposition than cattle of Hereford type. However, when ribeye area is expressed on a 100 kg carcass weight basis there was no difference (P<.10) found between groups. No differences were found in marbling score, quality grade or yield grade.

Dietary energy levels were revealed through least squares analysis to impact on the carcass traits recorded. Use of the high energy shelled corn ration in treatments one and three resulted in increased ribeye areas and more desirable yield grades than treatment two. Increasing the level of energy in the diet also resulted in increased 12th rib fat, decreased internal fat and higher quality grades. Energy level did not influence marbling scores, nor was there a difference noted in ribeye area when compared on an equivalent carcass weight basis.

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APPENDIX

TABLE A-1. Composition of Ration Treatments[1] (Dry Matter Basis).

| Constituent | International feed number | Dry Matter, % | Crude Protein, % | DE, Mcal/kg | ME, Mcal/kg | NEm, Mcal/kg | NEg, Mcal/kg | TDN, % |
|---|---|---|---|---|---|---|---|---|
| Treatment 1 | | | | | | | | |
| Shelled corn | 4-02-931 | 88 | 10.1 | 3.97 | 3.25 | 2.24 | 1.55 | 90 |
| Tend-R-Leen®[2] | -------- | 90 | 40.0 | ---- | ---- | ---- | ---- | 66.7 |
| Treatment 2 | | | | | | | | |
| Shelled corn | 4-02-931 | 88 | 10.1 | 3.97 | 3.25 | 2.24 | 1.55 | 90 |
| Corn silage | 3-28-250 | 33 | 8.1 | 3.09 | 2.53 | 1.63 | 1.03 | 70 |
| 48% beef concentrate[2] | -------- | 90 | 53.3 | ---- | ---- | ---- | ---- | 64.4 |
| Treatment 3 | | | | | | | | |
| Shelled corn | 4-02-931 | 88 | 10.1 | 3.97 | 3.25 | 2.24 | 1.55 | 90 |
| Corn silage | 3-28-250 | 33 | 8.1 | 3.09 | 2.53 | 1.63 | 1.03 | 70 |
| Tend-R-Leen® | -------- | 90 | 40.0 | ---- | ---- | ---- | ---- | 66.7 |

[1]All treatment groups supplemented with Rumensin® at manufacturers suggested levels.

[2]Products of Tennessee Farmers Cooperative.

TABLE A-2. Means for Subjective and Objective Measures for Steers at Slaughter.

| | Hereford | | Charolais | |
|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. |
| Slaughter weight (kg) | 441.5 | ±38.2 | 554.8 | ±71.0 |
| Carcass weight (kg) | 268.2 | ±27.0 | 318.9 | ±31.0 |
| Carcass fat (mm) | 13.0 | ±3.6 | 10.9 | ±3.3 |
| Ribeye area ($cm^2$) | 70.3 | 7.09 | 78.7 | 7.23 |
| KPH (%) | 2.0 | ±.50 | 2.4 | ±.52 |
| Yield grade | 2.9 | ±.56 | 2.8 | ±.65 |
| Marbling score | $Small^{30}$ | .78 | $Small^{60}$ | ±.70 |
| Quality grade[1] | 11.5 | ±1.1 | 11.8 | ±1.0 |
| Days on feed | 216.3 | ±41.7 | 315.8 | ±97.8 |
| Average Daily gain (kg/day) | .94 | ±.17 | .96 | ±.17 |
| Shoulder height (cm) | 111.2 | ±6.6 | 122.7 | ±6.9 |
| Hip height (cm) | 109.5 | ±6.8 | 121.9 | ±7.5 |
| Body length (cm) | 122.0 | ±7.7 | 132.4 | ±7.5 |
| Body depth (cm) | 61.9 | ±4.2 | 68.2 | ±5.2 |

[1]Quality grade - 9=low good, 10=average good, 11=high good, 12=low choice, 13=average choice, 14=high choice.

TABLE A-3. Correlation for Grader 1's Subjective Scores and Carcass and Performance Traits Measured.

| | Traits | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Grader 1 Scores | Final Wt. | Fat | REA | Marbling | Quality Grade | Yield Grade | A.D.G. | Days on Feed | Total Gain |
| Height | .76 | -.11 | .52 | .29 | .23 | -.01 | .15 | .58 | .72 |
| Length | .75 | -.14 | .51 | .29 | .22 | -.01 | .12 | .58 | .71 |
| Frame | .76 | -.12 | .51 | .29 | .23 | -.01 | .14 | .58 | .72 |
| Fat | -.44 | .18 | -.25 | -.10 | -.01 | .06 | -.22 | -.36 | -.54 |
| Trim | .22 | -.07 | .01 | .10 | .04 | .02 | -.16 | .30 | .25 |
| Muscle | .29 | .11 | .41 | .21 | .19 | -.04 | .07 | .10 | .15 |
| Head | .61 | -.04 | .54 | .26 | .17 | -.05 | .14 | .48 | .60 |
| Age | -.26 | .19 | -.25 | -.07 | .01 | .06 | -.10 | -.22 | -.31 |
| Depth | .02 | .02 | .12 | -.03 | .01 | .03 | -.16 | -.06 | -.14 |
| Final weight | .76 | -.13 | .50 | .29 | .23 | .003 | .15 | .57 | .72 |

TABLE A-4. Correlation for Grader 2's Subjective Scores and Carcass and Performance Traits Measured.

| | Traits | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Grader 2 Scores | Final Wt. | Fat | REA | Marbling | Quality Grade | Yield Grade | A.D.G. | Days on Feed | Total Gain |
| Height | .73 | -.13 | .50 | .25 | .21 | -.04 | .17 | .55 | .70 |
| Length | .72 | -.14 | .48 | .28 | .24 | -.01 | .16 | .54 | .69 |
| Frame | .73 | -.14 | .49 | .27 | .23 | -.03 | .16 | .56 | .70 |
| Fat | -.40 | .18 | -.22 | -.09 | -.03 | .07 | -.30 | -.32 | -.53 |
| Trim | .50 | -.12 | .26 | .15 | .05 | -.04 | .12 | .46 | .59 |
| Muscle | .30 | .05 | .29 | .11 | .07 | -.01 | .04 | .16 | .20 |
| Head | .53 | -.14 | .29 | .22 | .17 | .02 | .04 | .44 | .52 |
| Age | -.19 | .06 | -.16 | .06 | .10 | .10 | -.07 | -.21 | -.28 |
| Depth | .01 | .19 | .20 | .07 | .10 | -.05 | -.14 | -.07 | -.16 |
| Final weight | .72 | -.14 | .50 | .26 | .22 | -.04 | .17 | .55 | .70 |

TABLE A-5. Correlation of Mean Grader Scores with Carcass and Performance Traits.

| | Traits | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mean grader Scores | Final Wt. | Fat | REA | Marbling | Quality Grade | Yield Grade | A.D.G. | Days on Feed | Total Gain |
| Height | .75 | -.12 | .51 | .27 | .22 | -.03 | .16 | .57 | .72 |
| Length | .74 | -.14 | .50 | .28 | .23 | -.01 | .14 | .57 | .71 |
| Frame | .75 | -.13 | .51 | .28 | .23 | -.02 | .15 | .57 | .71 |
| Fat | -.44 | .19 | -.25 | -.10 | -.02 | .07 | -.28 | -.36 | -.56 |
| Trim | .44 | -.12 | .17 | .15 | .06 | -.01 | -.01 | .46 | .51 |
| Muscle | .33 | .09 | .40 | .18 | .15 | -.03 | .06 | .14 | .19 |
| Head | .62 | -.09 | .47 | .27 | .18 | -.03 | .10 | .50 | .61 |
| Age | -.25 | .13 | -.23 | .002 | .06 | .10 | -.10 | -.25 | -.33 |
| Depth | .01 | .12 | .19 | .02 | .06 | -.02 | -.17 | -.07 | -.18 |
| Final weight | .75 | -.14 | .51 | .28 | .23 | -.02 | .16 | .57 | .71 |

# VITA

William Joseph Bales, son of William White Bales and Mary Lynn (Shaver) Bales, was born in Morristown, Tennessee on June 14, 1959. He attended the Hamblen County school system, where he graduated from Morristown-Hamblen High School East in 1977. He enrolled in the University of Tennessee at Knoxville in the Fall of 1977. He graduated in June 1981 with a Bachelor of Science Degree in Animal Science. He was then employed as general manager for Bill Mullins Farms of Knoxville and Crossville, Tennessee. In September 1983, he returned to the University of Tennessee, Knoxville and received his Masters of Science Degree in Animal Science in March 1986.