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The effect of three controlled levels of fat thickness upon production and carcass characteristics in beef steers of similar age

William C. Huff

To the Graduate Council:

I am submitting herewith a thesis written by William C. Huff entitled "The effect of three controlled levels of fat thickness upon production and carcass characteristics in beef steers of similar age." 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 Husbandry.

C. B. Ramsey, Major Professor

We have read this thesis and recommend its acceptance:

H. J. Smith, C. S. Hobbs

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

September 15, 1965

To the Graduate Council:

I am submitting herewith a thesis written by William C. Huff entitled "The Effect of Three Controlled Levels of Fat Thickness upon Production and Carcass Characteristics in Beef Steers of Similar Age." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

C. B. Ramsey
Major Professor

We have read this thesis and recommend its acceptance:

Harold J. Smith

Charles S. Hobbs

Accepted for the Council:

Hilton A. Smith
Dean of the Graduate School

THE EFFECTS OF THREE CONTROLLED LEVELS OF FAT THICKNESS UPON PRODUCTION AND CARCASS CHARACTERISTICS IN BEEF STEERS OF SIMILAR AGE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

William C. Huff

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CHAPTER I

INTRODUCTION

Factors which affect demand for beef include population, disposable income of the consumer, tastes and preferences, substitute foods and environmental conditions influencing food consumption. These factors are not clearly separable in their influence upon demand and this list is not complete. However, these factors must be considered in beef production.

Since the population continues to increase, incomes continue to rise and a smaller proportion of the consumer dollar is spent for food, the consumer seems to be in a better position to purchase food than ever before. Therefore, the producer must continue to search for new ideas that will enable his product to compete with substitute foods such as eggs, milk and poultry. He must be in constant combat with various environmental conditions and economic disturbances in his search for ways to furnish the consumer with a product at a reasonable price.

One important problem that confronts the beef producer is the consumer's discrimination against excess fat. The consumer's belief that too much fat in the diet is unhealthy has motivated researchers to devote a considerable amount of time and money toward development of a beef animal that has a minimum degree of finish, but one that is acceptable in meat quality and can be economically produced.

The objectives of this study were to determine the effect of three controlled levels of fat thickness upon carcass and production characteristics and to determine the level of fatness which would produce the highest yield of trimmed retail cuts but still maintain acceptable quality in beef from steers of similar age.

CHAPTER II

REVIEW OF LITERATURE

I. PRODUCTION CHARACTERISTICS

Data showing the feedlot performance of steers fed varying levels of concentrates and roughage are abundant. This review deals with certain portions of the information available on the different methods of feeding.

Average daily gain. One factor affecting average daily gain is the proportion of concentrates and roughages in the ration. In a comparison of concentrate to roughage ratios of 1:1, 3:1 and 5:1, Richardson, Smith and Knox (1952) reported average daily gains of 2.13, 2.20 and 2.10 lb., respectively, for the three rations. McCroskey et al. (1958) fed rations with concentrate to roughage ratios of 35:65, 50:50, 65:35 and 80:20 to fattening steers and heifers. Average daily gains were 2.30, 2.27, 2.23 and 2.32 lb., respectively, for the four rations. Pope et al. (1957) compared concentrate to roughage ratios of 35:65, 50:50, 65:35 and 80:20 fed to fattening steers and heifers for approximately 160 days. Average daily gains of 1.93, 1.77, 1.61 and 1.78 lb. were reported for the four ratios, respectively.

Jones, Jones and Boyles (1941) reported average daily gains of 2.34 and 2.15 lb. for steers fed 51 and 71 per cent roughage rations, respectively. Average daily gains of 2.71, 2.66, 2.52 and 2.46 lb. were cited by Panish, Stanley and Shillingberry (1956) from steers fed concentrate to roughage ratios of 2:1, 1:1, 1:2 and 1:3, respectively. Cmarik, Webb and Cate (1957) compared three levels of concentrates and roughages fed to fattening yearling steers. The ratios contained 65, 55 and 45 per cent shelled corn and yielded average daily gains of 2.89, 2.85 and 2.71 lb., respectively.

When corn, sorghum, oat-vetch, and orchardgrass-ladino clover silages were compared by Hobbs et al. (1958), respective average daily gains of 1.71, 1.62, 1.58 and 1.78 lb. resulted. Average daily gains of 2.00, 2.06 and 2.16 lb. were cited by Perry et al. (1961a) for fattening steers fed 20, 40 and 60 per cent hay in their rations, respectively. Perry et al. (1961b) found that fattening beef calves had average daily gains of 2.07, 2.30, 2.46 and 2.40 lb. when fed rations containing 1.5 lb. of corn, one-third corn, two-thirds corn and a full-feed of corn, respectively. Silage and hay made up the remainder of each ration.

In general, the results from these experiments indicate that roughage can replace up to approximately 65 per cent of the grain in a ration for fattening animals without reducing average daily gain.

Feed efficiency. One phase of beef production which needs more study is the efficiency in converting feed to beef. Perry et al. (1961b) found that fattening beef calves required 738, 772, 813 and 807 lb. of feed per hundredweight gain when fed rations containing

1.5 lb. of corn, one-third corn, two-thirds corn and full feed of corn, respectively. Perry et al. (1961a) stated that 930, 1,017 and 1,019 lb. of feed were required per hundredweight gain for rations containing 20, 40 and 60 per cent hay, respectively. Hobbs et al. (1958) found no significant difference in feed required per hundredweight gain when corn, sorghum, oat-vetch and orchardgrass-ladino clover silages were fed to beef heifers.

When compared by Jones, Jones and Boyles (1941), the feed required per hundredweight gain was 930 and 1,000 lb. for rations containing 51 and 71 per cent roughage, respectively. Cmarik, Webb and Cate (1957) compared rations containing 65, 55 and 45 per cent shelled corn and found that 524, 536 and 541 lb. of TDN were required per hundredweight gain for the three rations, respectively. Upon making a comparison of concentrate to roughage ratios of 2:1, 1:1, 1:2 and 1:3, Panish, Stanley and Shillingberry (1956) found that the respective ratios required 615, 636, 611 and 592 lb. of TDN per hundredweight gain.

Pope et al. (1957) reported that the pounds of feed required per hundredweight gain were 1,192, 1,220, 1,161 and 1,015 lb. for concentrate to roughage ratios of 35:65, 50:50, 65:35 and 80:20, respectively. McCroskey et al. (1958) compared 35:65, 50:50, 65:35 and 80:20 concentrate to roughage ratios with fattening calves and reported that the feed required per hundredweight gain was 1066, 998, 996 and 875 lb., respectively. When concentrate to roughage ratios of 1:1, 3:1 and 5:1 were fed to fattening steers, Richardson, Smith and Knox (1952) observed feed required per hundredweight gain to be 1,093, 948 and 919 lb., respectively.

The observations of these researchers indicate that a ration with a concentrate to roughage ratio of approximately 2:1 generally will be utilized more efficiently than rations with other proportions of concentrates and roughages.

Costs and returns. Costs determine net returns and net returns determine whether a beef producer stays in business. Hobbs *et al.* (1958) compared four kinds of silage and reported returns per head of $28.09, $26.26, $19.52 and $24.06 from beef heifers fed corn, sorghum, oat-vetch and orchardgrass-ladino clover silages, respectively.

Knox (1957) fed rations containing either 5.3, 7.6 or 9.7 lb. of grain plus corn silage and hay free-choice to fattening yearling steers for 168 days. He found that the steers on the medium grain rations were $2.36 a head more profitable than those fed the most grain, and $8.47 a head more profitable than those fed the least grain.

Perry *et al.* (1961b) showed costs of $12.40, $13.00, $14.60 and $16.10 per hundredweight gain with steers fed rations containing 1.5 lb. of corn, one-third corn, two-thirds corn and a full-feed of corn, respectively. Each ration was fed along with a full-feed of corn silage.

Perry et al. (1961a) fed rations containing 20, 40 and 60 per cent hay as the only roughage to fattening beef steers. They cited costs of $19.30, $16.80 and $16.00 per hundredweight gain, respectively.

In general, these results indicate that rations that are approximately one-half to two-thirds roughage are the most profitable.

II. CARCASS CHARACTERISTICS

Dressing per cent. Rations that are higher in proportion of roughage are expected to result in a lower dressing per cent. Knox (1957) conducted an experiment to determine the amount of grain needed for fattening yearling steers. Three rations containing corn silage, alfalfa hay and either 5.3, 7.6 or 9.7 lb. of corn were fed to the steers for 168 days. The dressing per cent was significantly higher for those steers fed 9.7 or 7.6 lb. of corn than for those steers fed 5.3 lb. of corn. Jones et al. (1941) cited dressing per cents of 62.4 and 61.6 for steers fed 51 and 71 per cent roughage rations, respectively.

Richardson, Smith and Knox (1952) finished steers on rations with hay to concentrate ratios of 1:1, 1:3 and 1:5. The dressing per cents were 58.6, 60.0 and 60.3 for the three rations, respectively. The effect of rations containing 20, 40 and 60 per cent hay fed to steers were studied by Perry et al. (1961a). They reported respective average dressing per cents for the steers on the three rations to be 58.3, 59.0 and 59.2. Cmarik, Webb and Cate (1957) observed no significant difference in dressing per cent among steers fed rations containing 45, 55 and 65 per cent shelled corn.

The above experiments show that a ration high in roughage will tend to yield a lower per cent of carcass and that one high in concentrates will tend to produce a higher degree of finish and a higher dressing per cent.

Cutability. Fat thickness and carcass weight seem to be excellent predictors of the cutability of a carcass. Cole, Ramsey and Epley (1962) found that fat thickness over the *l. dorsi* and carcass weight were associated with over 70 per cent of the variation in carcass separable muscle and could be obtained easily and quickly. Ramsey, Cole and Hobbs (1962) found that one fat thickness measurement over the rib eye and carcass weight had a high negative association ($r = -.76$) with pounds of separable muscle in the carcass.

Bray (1938) compared grass-fed to grass plus concentrate-fed steers. He found the per cents of edible muscle to be 25.9 and 29.9 with the grass-fed steers having the larger amount.

Steers fed either corn silage plus legume hay in a drylot, ground ear corn plus soybean meal on pasture, low quality hay on pasture, or ground corn cobs plus molasses and vitamin A on pasture were compared by Phander (1955). He observed per cents separable carcass muscle of 51.32, 53.90, 55.51 and 55.67 for the four rations, respectively.

Winchester and Howe (1957) studied the effect of growth interruption in beef calves between the ages of 6 and 12 months. One of a pair of monozygotic twins was fed liberally while its co-twin was interrupted in growth for 6 months, then fed liberally to a grade equal to its liberally fed co-twin. They reported no significant difference in per cent fat and muscle, but a significant difference in per cent bone with the liberally-fed twin having the smaller per cent. This is in agreement with the work of Winchester and Ellis (1957) and Winchester, Hiner and Scarborough (1957). These researchers concluded that the larger per cent of bone could be attributed to the difference in age between the twins.

Studying the effect of early rate of gain on carcass merit, Garrigus, Johnson and Judge (1965) fed varying levels of corn silage and hay to fattening calves. They also studied the effect of corn silage, as compared with a conventional post-weaning low energy ration, on carcass quality. They found that, within weight groups, calves fed corn silage for the period following weaning consistently had more carcass yield than those fed hay. Within the 625 to 750 lb. weight groups, calves fed silage had more pounds of boneless, trimmed round, rib, loin and chuck, and edible portion than calves fed hay. However, on a per cent of carcass basis, cutability and edible portion always favored the hay-fed calves. This was attributed to the fact that the hay-fed calves had more G. I. tract, more bone, less muscle and less fat at these light weights.

Fat thickness. Garrigus, Johnson and Judge (1965) compared silage and hay for fattening beef calves. Those calves fed corn silage consistently had more fat cover than those fed hay. Also, calves fed corn silage until they reached 750 lb., then fed corn until they reached 900 lb., had more fat cover than calves fed hay up to 750 lb. then corn up to 900 lb.

Young, Branaman and Deans (1962) compared a limited to a delayed full-feed in beef calves. The limited-fed calves received a full-feed of corn silage, 0.25 lb. of cottonseed meal per hundred pounds body weight and 1.25 lb. of corn per hundred pounds body weight throughout the experiment. The delayed full-feed ration consisted of a full feed of corn silage and 0.25 lb. of cottonseed meal per hundred pounds body weight for 98 days, then a full-feed of corn. They found average fat thickness to be 21.9 and 20.0 mm. for the limited and delayed full-feed rations, respectively.

Carroll, Ellsworth and Kroger (1963) studied compensatory carcass growth in steers following protein and energy restrictions. The steers in group 1 were slaughtered at 243 days of age. Groups 2 and 3 were fed barley straw and sudan hay and barley straw, sudan hay and 1.6 lb. of cottonseed meal, respectively, for 168 days. Fat thicknesses for groups 1, 2 and 3 were 3.1, 2.6 and 2.4 mm., respectively.

Work by the above researchers indicates that a ration high in roughage will produce a lesser degree of finish than a ration high in concentrates.

Rib eye area. Research indicates that rib eye area is of little value in predicting separable carcass lean. Cole, Orme and Kincaid (1960) found that rib eye area was associated with only 18 per cent of the variation in separable carcass lean, and from 5 to 30 per cent of the variation in the separable lean from the more valuable cuts of beef. When carcass weight was held constant, l. dorsi area was associated with only 4 per cent of the variation in separable carcass muscle.

Brungardt and Bray (1963) reported that rib eye area accounted for approximately 20 per cent of the variation in the yield of retail cuts from the rib, chuck, loin and round. However, the standard partial regression coefficient of per cent retail yield on l. dorsi area was 0.02 when left-side weight, per cent kidney knob, per cent trimmed round, and a single fat measurement over the 12th rib were held constant.

Garrigus, Johnson and Judge (1965) reported rib eye areas of 9.74 and 7.51 square inches for calves fed silage and hay up to 750 lb., respectively. However, they noted that calves fed corn silage or hay up to 750 lb. then fed corn up to 900 lb. yielded rib eye areas that were not significantly different.

Winchester and Howe (1957) delayed the growth in one of a pair of monozygotic twins between the ages of 6 and 12 months then finished the twin to a grade equal to its liberally fed co-twin. They concluded that there was no significant difference in rib eye area between the two twins.

Matthews and Bennett (1962) fed rations to produce either fast or slow gain to steers. They observed no significant difference between average area of l. dorsi from steers fed the rations to produce either fast or slow gains.

Carcass grade. Perry et al. (1961a) fed rations containing 20, 40 and 60 per cent hay to fattening steers. They found no significant difference in carcass grade among the three treatments. The 20 per cent hay ration yielded 1 low choice, 6 high good, 2 average good and 2 low good carcasses; the 40 per cent ration yielded 1 average choice, 2 low choice, 5 high good and 2 average good carcasses; and the 60 per cent ration yielded 4 low choice, 3 high good and 4 average good carcasses.

In studies designed to determine the relative effect of continuous and interrupted growth in beef calves, Winchester and Howe (1957) and Winchester and Ellis (1957) noted no significant difference in carcass grade between a co-twin interrupted in growth between the ages of 6 and 12 months and its liberally fed co-twin.

Young, Branaman and Deans (1962) observed no significant difference in carcass grade of steers fed a limited energy ration and a delayed full-feed ration. Phander (1955) noted that low quality hay fed on pasture did not produce a lower carcass grade than corn silage or hay.

Matthews and Bennett (1962) fed rations to produce slow, fast to slow, and fast growth to beef steers for 140 days. The slow growth ration consisted of a full-feed of alfalfa hay; the fast to slow ration consisted of a full-feed of concentrates for 49 days then a liberal feeding of alfalfa hay for 91 days; and the fast growth ration consisted of a full-feed of concentrates. Significantly higher carcass grades were observed for the steers fed the fast growth rations and the fast to slow growth rations than for those steers fed the ration to produce slow growth.

In general, work by the above researchers indicates that a ration can consist of approximately two-thirds roughage without producing a lower carcass grade.

Meat quality factors. Garrigus, Johnson and Judge (1965) reported that an increase in degree of finish was accompanied by an increase in marbling. Steers fed corn silage or hay up to 625 lb. had only traces of marbling, whereas, those fed silage up to 750 lb. then corn until they reached a weight of 900 lb. had a modest amount of marbling. In steers fed corn silage to 900 lb. of weight, then corn to 1,000 lb., the marbling score was slightly abundant.

Bray (1938) found color of muscles darker and less desirable in grass-fattened steers than in grass plus grain-fattened steers. The grain-fattened steers had a slightly firmer texture than the grass-fattened steers. Phander (1955) found that steers fed on a high plane of nutrition had significantly more marbling than those fed on a low plane of nutrition. Steers fed on a low nutritional plane had significantly more fat deposited on the outside of the carcass.

Matthews and Bennett (1962) studied the effect of rate of gain on meat quality and noted that fast-gaining steers had significantly more marbling than those which gained more slowly. Muscle color scores were not significantly different between treatments.

These experiments indicate that a greater amount of external finish tends to produce more marbling.

III. ULTRASONIC EVALUATION OF LIVE ANIMALS

Early work indicated promise in estimating fat thickness in cattle with ultrasonic devices. Temple (1956) compared live estimates to actual fat thickness using 60 head of yearling steers and heifers. He found a correlation of 0.39 ($P < .01$) between the single readings obtained with the somascope and the fat reading determined on the carcass with calipers.

Price et al. (1958) reported that ultrasonic techniques showed more promise in estimating muscling and fatness in swine than in beef cattle. However, more recent work with ultrasonic instruments has proved to be of greater value with beef cattle.

Hedrick et al. (1962) estimated fat thickness on 203 cattle with a Branson Sonoray Model 5 ultrasonic instrument and compared these estimates with actual fat thickness. The hair was clipped over the area to be scanned and a series of depth measurements were taken between the 12th and 13th ribs. The cattle were slaughtered and tracings were made of actual fat thickness. The correlation coefficients between live estimates and actual fat thickness varied from 0.11 to 0.63. Low correlations existed between measurements of a group of cattle in which the spinous processes were scribed during slaughter. Significant relationships existed between estimated and actual fat thickness of the groups in which the spinous processes were not scribed. They concluded that ultrasonic instruments were sufficiently accurate for estimating fat thickness in cattle.

Stouffer et al. (1961) compared ultrasonic and actual fat thickness data on 327 head of cattle. Correlations of 0.04, 0.42 ($P < .01$), 0.54 ($P < .01$), 0.32 ($P < .01$) and 0.35 ($P < .01$) were observed on the groups of cattle. They concluded that the lowest correlation coefficient was the result of a small number (15) of individuals within that group. They stated that underestimations of fat thickness probably were the result of pressure being applied to the transducer. This pressure tended to compress the fat in the region being scanned.

Brown et al. (1964) obtained ultrasonic estimates of fatness on 20 bulls using a Branson Model 52 ultrasonic instrument with scanning device. They found a correlation of 0.46 between actual and estimated fat thickness.

Williams (1965) reported that from 80 to 85 per cent of the variation in actual fat thickness could be accounted for by ultrasonic estimates.

Shepard (1964) compared estimated fat thickness to actual fat thickness at slaughter on 49 cattle. He reported that, within groups, estimated fat thickness was associated with from 24 to 51 per cent of the variation in actual fat thickness.

Results from the above experiments indicate that considerable progress has been made in the ultrasonic evaluation of live animals and that ultrasonic instruments are useful for estimating fat thickness in live beef animals.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. DATA SOURCE AND ASSIGNMENT TO TREATMENTS

Data were collected on 36 Hereford steers from the 1964 calf crop at the Tennessee Agricultural Experiment Station at Knoxville. The steers, representative progeny of three sires, were selected off their dam at the end of the grazing season. The selected cattle were as nearly alike in initial age, weight, and grade as was possible. The steers were placed on a high roughage ration containing antibiotics until the experiment was started on December 15.

The 36 steers were divided into 12 lots of 3 steers per lot with each lot being represented by 1 progeny from each of 3 sires. Each of the 3 treatments was replicated 4 times to give 12 steers per treatment. Each lot contained approximately 360 square feet of floor space, or on a per animal basis, each steer was allotted approximately 120 square feet. Each pen was equipped with an automatic waterer which allowed each steer free access to water. Each steer also had free access to a mineral mixture of equal parts salt and dicalcium phosphate.

II. EXPERIMENTAL RATIONS AND FEEDING

Three rations, which constituted three treatments, were fed. Ration 1 was formulated with the objective of producing a fat thickness over the rib eye of from 3 to 5 mm. on the steers at the end of the feeding period. Rations 2 and 3 were formulated to develop fat thicknesses from 8 to 10 mm. and from 13 to 15 mm., respectively. Composition of the rations is shown in Table I.

Treatments 1 and 2 received all of the corn silage they would consume without excessive waste. Treatment 3 received a full-feed of corn with excessive wastage also being avoided. The steers were fed twice daily and the amount of feed not consumed was weighed before the next feeding and substracted from the total feed fed to obtain the total feed consumed. The animals were fed in a covered barn and the silage was removed from the silo at the time of feeding to insure freshness. The steers were fed their respective ration for approximately 150 days in pens equipped with a feed box approximately 12 X 3 feet.

III. WEIGHTS

Individual weights were taken on two consecutive days and the average of these two weights was used as the initial weight. Individual weights also were taken every 28 days. Each animal was weighed on two consecutive days at the end of the feedlot period. The average of these two weights was used as the off-feed weight.

IV. SOMASCOPE TECHNIQUE

Branson Sonoray Model 52 and Branson Sonoray Model 12 ultrasonic instruments were used to estimate fat thickness on each steer

TABLE I

COMPOSITION OF RATIONS

Ingredient	Ration 1	Ration 2	Ration 3
No. 2 yellow corn, lb.	none	4.0	*ad. lib.*
Corn silage, lb.	*ad. lib.*	*ad. lib.*	10.0
Grass-legume hay, lb.	4.0	4.0	4.0
Cottonseed meal, lb.	1.5	1.5	1.5

as the experiment progressed. The Model 52 was equipped with a tissue scanning device and a Polaroid Land Camera Model 110B as described by Shepard (1964). The resulting Polaroid prints (somagrams) were a cross-sectional representation of the fat thickness of each steer. Disregarding time spent to restrain the animals, only a few seconds were required to obtain a representation of the cross-sectional area. The Model 12 ultrasonic instrument was used to obtain a direct reading of fat thickness at the last scan date before slaughter. These readings were taken at a point approximately three-fourths the length of the *l. dorsi* from the chine end.

The animals were restrained in a Teco cattle chute, equipped with a headgate. Before each steer was scanned, the hair was clipped with Oster small animal clippers over the *l. dorsi* muscle in the 12th-13th rib region. Mineral oil was applied to the clipped area to insure proper contact between the hide and transducer. The speed and direction of the scanner were controlled from the scanning unit. As the scanner passed over the desired location, electrical energy was converted by the transducer into high frequency sound waves and directed into the animal tissues. Echoes, resulting from differences in density of tissue, were reflected back to the transducer, converted into electrical energy, transmitted to the oscilloscope, and recorded on film in the camera set for time exposure.

Each steer was scanned every 28 days throughout the experiment to obtain an estimate of the progress each steer was making toward the desired level of fat thickness.

V. SLAUGHTER PROCEDURE

The steers were slaughtered in four groups at approximately four-day intervals. One-fourth of the steers in each treatment were slaughtered at random each time. An effort was made to have the steers in each treatment at their respective desired average fat thicknesses on a common slaughter date. A compromise in slaughter date was necessary because the range in average fat thickness among the three treatments was not as great as expected. The steers were trucked approximately 10 miles to the East Tennessee Packing Company at Knoxville to be slaughtered. They were allowed a 24-hour shrinkage period without feed but had free access to water prior to slaughter.

The carcasses were chilled in the approximately 3°C. cooler at East Tennessee Packing Company for 48 hours before ribbing. After chilling, carcass length was measured from the anterior edge of the first rib to the anterior edge of the aitch bone. A direct measurement of fat thickness was taken to the nearest millimeter between the 12th and 13th ribs at a point three-fourths the length of the <u>l. dorsi</u> from the chine end. A tracing of each <u>l. dorsi</u> cross section was made, and carcass grade, conformation grade, maturity, marbling score, and estimated per cent kidney, pelvic and heart fat were obtained from a federal grader. The left side of each carcass was purchased and shipped to the Meat Laboratory for the collection of carcass yield data.

In the carcass, rump length was measured from the anterior extremity of the ilium (point A) to the posterior extremity of the ischium (point B) shown in Figure 1. External leg length was measured from the distal extremity of the tarsal bones (point E) to point C (midway between points A and B). Internal leg length was measured from point E to the anterior edge of the aitch bone. Hock to hip length was obtained by measuring from the distal extremity of the tibia (point D) to point C. Loin length was measured from the anterior edge of the aitch bone to point F (down to and including one-fourth of the 8th lumbar vertebra from the lumbo-sacral joint).

The carcasses were cut into wholesale cuts as described by Wellington (1953). The round, loin, rib and chuck were further cut into trimmed, partially boneless, retail cuts. The chine bones were removed from the chuck roasts, sections of ribs and sternum were removed from the arm pot roasts, chine bones and rib ends were removed from the rib roasts, sacral vertebrae were removed from the sirloin steaks, and all bones were removed from the rump roasts. Each retail cut was trimmed to an outside fat cover of approximately three-eights inch. However, not all animals had as much as three-eights inch of fat cover. Area of the biceps femoris muscle was measured at a point 37.5 per cent of the distance from point C toward point D (Figure 1, page 23).

The first-cut club steak was kept at room temperature for 30 minutes. Subjective numerical scores then were given for muscle color, muscle texture, firmness of muscle, and marbling texture by

Figure 1. Location of length measurements on the beef hindquarter.

a meat researcher of the Animal Husbandry-Veterinary Science Department using the scoring system as shown in Table II and described in LS Instruction AMS-LSG 1 (U.S.D.A., 1963). Higher scores represented more desirable qualities within each trait. Fat color was scored with the use of Munsell Color Paddles.

Areas of *l. dorsi* and *biceps femoris* muscles were measured to the nearest 0.01 square inch with a compensating polar planimeter. Dressing per cent was calculated on a chilled carcass and shrunk slaughter weight basis. Chilled carcass weight was calculated from hot carcass weight using a 2.5 per cent cooler shrink.

VI. STATISTICAL ANALYSIS

These data were analyzed by the method of least squares as outlined by Harvey (1960). Kramer's (1957) modification of Duncan's (1955) Multiple Range Test was applied to test the significance of difference between treatments where the "F" test was significant in the carcass data. Duncan's (1955) Multiple Range Test was used to test the significance of difference between treatments where the "F" test was significant in the production data.

TABLE II

NUMERICAL SCORES FOR MEAT CHARACTERISTICS

Numerical score	Characteristic			
	Muscle color	Muscle texture	Muscle firmness	Marbling texture
1	Black	Very coarse	Extremely soft	Coarse
2	Very dark red	Coarse	Very soft	Medium
3	Dark red	Slightly coarse	Soft	Fine
4	Moderately dark red	Slightly fine	Slightly soft	
5	Slightly dark red	Moderately fine	Moderately firm	
6	Cherry red	Fine	Firm	
7	Very light cherry red	Very fine	Very firm	

CHAPTER IV

RESULTS AND DISCUSSION

I. PRODUCTION CHARACTERISTICS

Thirty-six Hereford male calves were selected off their dam at the end of the 1964 grazing season at the Tennessee Agricultural Experiment Station at Knoxville. They were castrated and started on three experimental rations formulated to produce three levels of fat thickness. At weaning, the calves allotted to treatments 1, 2 and 3 had respective average daily gains of 1.88, 1.92 and 1.96 lb., type scores of 11.2 (high good), 12.2 (low choice) and 11.6 (high good); and all three treatments had a condition grade of high standard. The steers were put on feed on December 15, 1964. The estimated fat thicknesses at the first scan date (January 12, 1965) for treatments 1, 2 and 3 were 4.7, 5.3 and 5.7 mm., respectively. The steers were to be slaughtered at a similar age when treatments 1, 2 and 3 had fat thicknesses of from 3 to 5, 8 to 10 and 13 to 15 mm., respectively. A brief summary of the feedlot performance of the three treatments is shown in Table III.

Average daily gain. The analysis of variance revealed a significant difference in average daily gain among the three treatments for the feedlot period. Treatments 1, 2 and 3 had average daily gains of 1.14, 1.38 and 1.93 lb., respectively.

TABLE III

SUMMARY OF AVERAGE FEEDLOT PERFORMANCE

Item	Treatment 1	Treatment 2	Treatment 3
No. of animals	12	12	11[a]
Days on feed	150	150	150
Avg. wt. and gain per head, lb.			
Initial wt.	613	610	623
Final wt.[b]	784	817	912
Total gain[b]	171	207	289
Avg. daily gain[b]	1.14	1.38	1.93
Feed cost per cwt. gain[c]	$21.68	$23.65	$24.36
Feed required per head, lb.			
Corn silage[d]	5,053	4,215	1,713
Grass-legume hay[e]	426	411	340
Shelled corn[f]	47	652	1,956
Cottonseed meal	235	239	214
Feed required per cwt. gain, lb.			
Corn silage[d]	2,976	2,048	598
Grass-legume hay[g]	251	201	119
Shelled corn[f]	28	318	684
Cottonseed meal[g]	139	116	84

[a]One died last day of experiment, cause unknown.

[b]Treatment $1 < 2 < 3$ ($P < .05$).

[c]Feed cost based on following prices: Corn silage $8 per ton, Grass-legume hay $35 per ton, Corn $1.40 per bu. and Cottonseed meal $70 per ton.

[d]Treatment $1 > 2 > 3$ ($P < .01$).

[e]Treatment 1 and $2 > 3$ ($P < .05$).

[f]Treatment $1 < 2 < 3$ ($P < .01$).

[g]Treatment $1 > 2 > 3$ ($P < .05$).

The difference in average daily gain is considerably less between treatments 1 and 2 than between treatments 2 and 3. Keeping in mind that treatment 3 received a full-feed of corn, treatment 2 received a full-feed of corn silage plus 4 lb. of corn per head per day, and treatment 1 received a full-feed of corn silage and no corn, as indication that corn will produce a higher average daily gain is present in this data. This is in general agreement with the work of Richardson, Smith and Knox (1952), Pope et al. (1957), Jones, Jones and Boyles (1941), Cmarik, Webb and Cate (1957) and Perry et al. (1961b). These researchers reported that an increase in roughage in the ration resulted in lower average daily gains.

Feed efficiency. TDN required per hundredweight gain for treatments 1, 2 and 3 was 835.8 lb., 835.4 lb. and 784.3 lb., respectively. This is in general agreement with the work of Perry et al. (1961a), Jones, Jones and Boyles (1941), Panish et al. (1956) and Cmarik, Webb and Cate (1957), who stated that high roughage rations required more feed per hundredweight gain than rations that were high in concnetrates.

This large difference in feed required per hundredweight gain can be attributed to the full-feed of corn silage received by the steers in treatments 1 and 2 as compared to the full-feed of corn per head per day received by the steers in treatment 3. The three treatments were fed equal amounts of hay but treatment 1 consumed significantly ($P < .01$) more than treatment 2 and treatment 2 consumed significantly ($P < .01$) more than treatment 3. This indicates that the full-feed of corn received by the steers in treatment 3 caused them to consume less hay and more corn because of the preference of corn over hay. Also, treatment 2 steers received 4 lb. of corn per head per day and rejected part of their hay in favor of the corn they received.

No significant difference was observed in the amount of cottonseed meal required per hundredweight gain among the three treatments.

Feed costs. Total gain per head for treatments 1, 2 and 3 was 171, 207 and 288 lb., respectively. Feed costs per hundredweight gain for treatments 1, 2 and 3 were $21.68, $23.65 and $24.36, respectively. Feed cost per head was significantly higher for treatment 3 than for treatment 2 ($P < .01$) and significantly higher for treatment 2 than for treatment 1 ($P < .01$). However, when total gain per head was considered, the three treatments were not significantly different in feed cost per hundredweight gain. This is in general agreement with Perry *et al.* (1961a), who stated that rations containing 60 per cent hay cost less per hundredweight gain than rations containing 20 per cent hay. However, Knox (1957) reported that medium grain rations fed with corn silage were more profitable than rations containing a large or small amount of grain.

These data indicate that more total gain can be obtained from steers that are fed a full-feed of corn than from steers that are fed a full-feed of corn silage, however, the total cost will be higher for the corn-fed steers. Therefore, no appreciable difference will be found in feed cost per hundredweight gain.

II. CARCASS CHARACTERISTICS

Dressing per cent. The dressing per cents for steers on treatments 1, 2 and 3 were 56.4, 57.3 and 59.6, respectively, with the corn-fed steers in treatment 3 dressing significantly higher than those steers fed corn silage in treatment 1 ($P < .01$). Treatments 1 and 2 did not differ significantly. This is in general agreement with the work of Jones, Jones and Boyles (1941) and Richardson, Smith and Knox (1952). These researchers found that cattle fed high concentrate rations yielded higher dressing per cents than those fed high roughage rations. Knox (1957) found that dressing per cent of steers of similar age was higher for those steers that had the higher degree of finish.

Fat thickness. The analysis of variance revealed no significant difference in ultrasonically estimated fat thickness over the *l. dorsi* among treatments for the first scan with the Sonoray Model 52 ultrasonic instrument on January 12, 1965. This scan date was approximately one month after the start of the experimental feeding period (Table IV).

TABLE IV

LEAST SQUARE MEANS FOR ESTIMATED AND ACTUAL FAT THICKNESS

Scan and date	Fat thickness, mm. Treatment 1	2	3
Scan 1 - January 12, 1965	4.7	5.3	5.7
Scan 2 - February 10, 1965	5.0	5.7	6.2
Scan 3 - March 9, 1965[a]	5.8	6.7	7.5
Scan 4 - April 19, 1965[b]	6.4	7.5	11.0
Actual at slaughter[b]	7.2	9.2	13.2

[a]Treatment 1 < 2 < 3 ($P < .05$).

[b]Treatment 1 < 2 < 3 ($P < .01$).

Likewise, scan 2, which was conducted on February 10, 1965, revealed no significant difference in estimated fat thickness among the three treatments.

When the third ultrasonic scan was conducted on March 9, 1965, the estimated fat thicknesses for treatments 1, 2 and 3 were 5.6, 6.7 and 7.5 mm., respectively. Differences between treatments were significant ($P < .05$). The steers in treatment 1 had already surpassed their maximum desired level of fat thickness; those in treatment 2 were only 1.3 mm. under their minimum desired level, and those in treatment 3 were 5.5 mm. under their minimum desired level.

At the fourth ultrasonic scan date, April 19, 1965, the estimated fat thickness for treatments 1, 2 and 3 was 6.4, 7.5 and 10.8 mm., respectively. Differences between treatments were significant at the 1 per cent level of probability. The steers in treatment 1 were 1.4 mm. over their maximum designated fat level; treatment 2 steers were within 0.5 mm. of their designated minimum level and treatment 3 steers were within 2.2 mm. of their designated minimum level.

On May 11, 1965, the fifth ultrasonic scan was conducted and the average estimated fat thickness revealed that the steers in treatment 1 were considerably over their maximum designated level while those in treatments 2 and 3 were within their designated fat thickness level ranges. Therefore, plans were made to slaughter the steers on May 14, 18, 21 and 25. The data for scan five is not presented because some of the somagrams were lost. Actual carcass fat thickness over the l. dorsi for treatments 1, 2 and 3 was 7.2, 9.2 and 13.2 mm., respectively, with treatment differences being significant ($P < .01$).

The rate of increase in fat thickness over the l. dorsi muscle was almost equal for the three treatments up until scan 3 on March 9, 1965 as shown in Figure 2. However, at this point in the experiment, a marked difference was noticed in the rate of fat thickness increase among the three treatments. Treatment 1 continued to increase in fat thickness at approximately the same rate until the experiment was terminated. Treatment 2 steers increased in fatness at approximately the same rate as those in treatment 1 until the next scan date on April 19, 1965, then their rate of increase became greater until slaughter. The steers in treatment 3 began a very rapid increase in the rate of fat deposition at the third scan date on March 9, 1965 and continued this rapid rate until the end of the experimental feeding period. These results indicate that the steers in treatment 3, which gained an average of 1.93 lb. daily during the feeding period, began an accelerated fattening phase on or near the third scan date (March 9, 1965). The steers in treatment 2 gained an average of 1.38 lb. per day and began their fattening phase approximately 40 days later than did treatment 3. On the other hand, steers in treatment 1, which gained only 1.14 lb. per day, showed little change in rate of fat deposition throughout the feeding period.

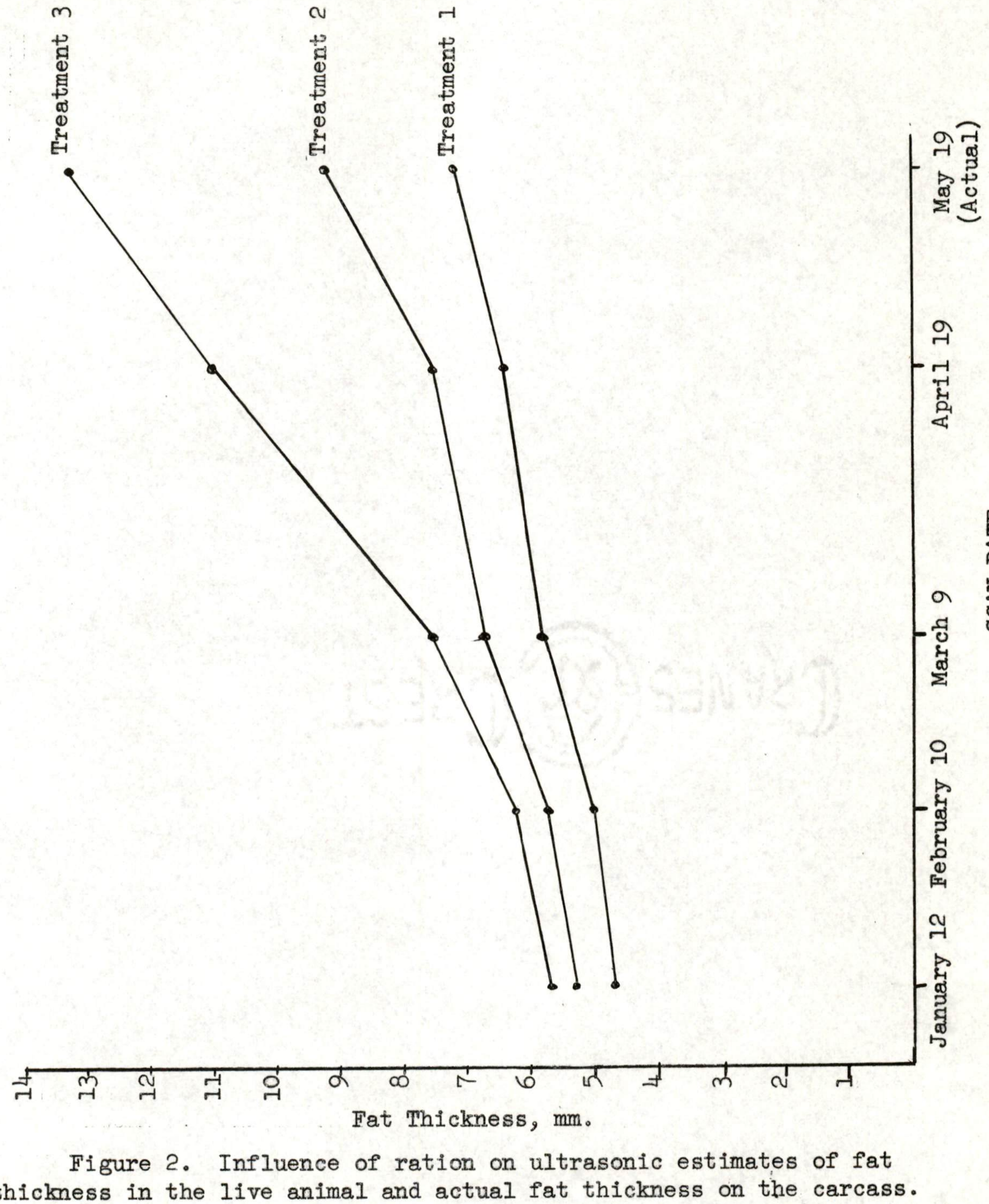

Figure 2. Influence of ration on ultrasonic estimates of fat thickness in the live animal and actual fat thickness on the carcass.

Carcass measurements. Square inches of rib eye area for treatments 1, 2 and 3 were 9.1, 9.1 and 9.5, respectively (Table V). Differences among the three treatments were not significant. However, on a per cent of carcass basis, treatment 1 steer carcasses yielded more rib eye area than treatments 2 and 3 ($P < .05$). This is in general agreement with the work of Garrigus, Johnson and Judge (1965) who stated that calves fed corn silage up to 750 lb., then fed corn until they reached 900 lb., yielded larger rib eyes, on a per hundredweight of carcass basis, than those fed a hay ration up to 750 lb., then corn up to 900 lb. These data indicated that reduced daily gain and finish were not detrimental to the development of area of the l. dorsi muscle in beef cattle.

No significant differences were observed in carcass, external leg, internal leg, hock to hip and rump lengths among the three treatments. Thus, reducing the daily gain by increasing the amount of corn silage in the ration did not have a significant effect on skeletal development as measured by these distances between skeletal reference points.

Forequarter cutout. Forequarter weights shown in Table VI reveal that the forequarters from the corn-fed steers in treatment 3 weighed significantly more than the forequarters from the corn and corn silage-fed steers in treatment 2 ($P < .01$), and treatment 2 forequarters were significantly heavier than those from the corn silage-fed steers in treatment 1 ($P < .01$). However, on a per cent of side

TABLE V

LEAST SQUARE MEANS FOR CARCASS MEASUREMENTS

Measurement	Treatment 1	Treatment 2	Treatment 3
Rib eye area, sq. in.	9.1	9.1	9.5
Rib eye area per cwt. carcass, sq. in.[a]	2.0	1.7	1.7
Carcass length, cm.	110.8	111.2	112.3
External leg length, cm.	77.6	76.2	77.0
Internal leg length, cm.	71.6	71.0	71.5
Hock to hip length, cm.	70.0	68.9	69.4
Rump length, cm.	42.3	41.5	43.2

[a]Treatment 1 > 2 and 3 ($P < .05$).

TABLE VI

LEAST SQUARE MEANS FOR CUTOUT DATA FROM FOREQUARTER

Component	Treatment 1	Treatment 2	Treatment 3
Side wt., lb.[a]	219.7	233.1	265.9
Forequarter wt., lb.[a]	112.6	119.7	136.9
Forequarter wt. as per cent of side wt.	51.3	51.1	51.3
Wholesale rib wt., lb.[a]	18.6	20.2	24.3
Rib cuts wt., lb.[a]	13.7	14.7	16.7
Chuck wt., lb.[a]	61.4	63.3	70.1
Chuck cuts wt., lb.[b]	35.9	37.4	39.3
Plate wt., lb.[a]	16.7	18.4	23.3
Brisket wt., lb.[a]	7.8	8.9	10.1
Foreshank wt., lb.	8.4	9.1	9.2

[a]Treatment 1 < 2 < 3 ($P < .01$).

[b]Treatment 1 < 2 < 3 ($P < .05$).

weight basis, no significant difference was found among the three treatments. This indicates that the corn-fed steers yielded more total pounds from the forequarter, however, this difference was due to the fact that they weighed more at slaughter than the corn silage-fed steers.

Likewise, the weights of the wholesale chuck, rib, plate and brisket differed significantly among the three treatments. The steers in treatment 3 yielded significantly more total pounds of these cuts than the steers in treatments 1 and 2 ($P < .01$) and the steers in treatment 2 yielded significantly more total pounds than the steers in treatment 1 ($P < .01$). No significant difference was observed in weight of the foreshank among the three treatments. The weight of the trimmed, retail cuts from the rib and from the chuck also differed significantly among the three treatments with the fatter, heavier carcasses having the heavier weights of retail cuts.

The data indicate that steers fed the full-feed of corn yielded significantly more total pounds of cutout from the forequarter than the steers fed the full-feed of corn silage. This is in general agreement with the work of Garrigus, Johnson and Judge (1965). These researchers reported that steers fed corn silage to 900 lb. yielded carcasses that weighed less than steers fed corn silage up to 750 lb., then fed corn until they reached a weight of 900 lb.

Hindquarter cutout. In the current study, the hindquarters from the corn-fed steers in treatment 3 weighed significantly more than those from the corn silage and corn-fed steers in treatment 2 ($P < .01$), and treatment 2 steers had significantly heavier hindquarters than the corn silage-fed steers in treatment 1 ($P < .01$). However, on a per cent of side weight basis, no significant difference was found among the three treatments (Table VII). These results are similar to those found with forequarter weight and per cent.

Evidence that a higher degree of finish required more trimming of the round is present in the round yield weights among the three treatments. The corn-fed steers in treatment 3 yielded significantly heavier untrimmed rounds than the corn and corn silage-fed steers in treatment 2 ($P < .01$), and the steers in treatment 2 yielded significantly heavier untrimmed rounds than the corn silage-fed steers in treatment 1 ($P < .01$). However, no significant difference was found in weight of the trimmed rounds among the three treatments. Therefore, the difference in weight of the untrimmed rounds among the three treatments was due to the greater amount of external finish on the rounds of the faster-gaining steers. This is in general agreement with the work of Garrigus, Johnson and Judge (1965) who reported that silage-fed calves yielded more trimmed round than slower-gaining, hay-fed calves. However, on a per cent of carcass basis, trimmed round yield consistently favored the hay-fed calves.

Flank and kidney knob weights were significantly heavier for the corn-fed steers in treatment 3 than for the corn and corn silage-fed steers in treatment 2 ($P < .01$) and were significantly heavier for the steers in treatment 2 than for the corn silage-fed steers

TABLE VII

LEAST SQUARE MEANS FOR CUTOUT
DATA FROM HINDQUARTER

Component	Treatment 1	Treatment 2	Treatment 3
Side wt., lb.[a]	219.7	233.1	265.9
Hindquarter wt., lb.[a]	107.1	113.4	125.9
Hindquarter wt. as per cent of side wt.	48.8	48.9	48.7
Untrimmed round wt., lb.[a]	53.6	56.2	59.3
Trimmed round wt., lb.	52.1	54.1	54.5
Round cuts wt., lb.[a]	35.4	36.7	39.0
Loin wt., lb.[a]	35.0	36.0	37.4
Loin cuts wt., lb.	30.1	30.4	32.3
Kidney knob wt., lb.[a]	5.8	7.3	10.6
Flank wt., lb.[a]	12.7	14.3	18.8

[a]Treatment 1 < 2 < 3 (P < .01).

in treatment 1 ($P < .01$). Weight of the loin was not significantly different among the three treatments. The corn-fed steers in treatment 3 yielded significantly more total pounds of retail cuts from the round than the corn and corn silage-fed steers in treatment 2 ($P < .01$) and treatment 2 yielded significantly more total pounds than the corn silage-fed steers in treatment 1 ($P < .01$). This difference may be attributed to the significant difference in carcass weight among the three treatments.

Physical separation of round. The weights of physically separable muscle and bone from the round were not significantly different among the three treatments. Thus, the steers which were fed to gain at reduced rates apparently were not significantly hindered in their muscular or skeletal development. This is further evidenced by the lack of a significant difference among the three treatments in area or weight of the biceps femoris, a major muscle of the round (Table VIII).

The corn-fed steers in treatment 3 did yield a significantly heavier weight of round separable fat than the steers in treatments 1 or 2 ($P < .01$). The difference between treatments 1 and 2 also was significant. However, the fat thickness over the biceps femoris muscle was not significantly different among the three treatments.

Quality factors. Marbling scores were significantly different ($P < .01$) among the three treatments with the fatter, faster-gaining animals having the higher scores. This is in agreement with the work

TABLE VIII

LEAST SQUARE MEANS FOR CUTOUT AND PHYSICAL SEPARATION FROM ROUND

Component	Treatment		
	1	2	3
Hindshank wt., lb.	8.1	8.4	8.5
Separable muscle wt., lb.	31.5	31.9	32.5
Separable fat wt., lb.[a]	6.8	8.1	9.4
Separable bone wt., lb.	5.7	5.8	5.4
Biceps femoris area, sq. in.	15.1	15.1	15.4
Biceps femoris wt., lb.	7.6	7.7	8.1
Fat over *biceps femoris*, mm.	3.0	3.0	3.2

[a]Treatment 1 < 2 < 3 ($P < .01$).

of Garrigus, Johnson and Judge (1965) who found that a higher degree of finish resulted in a marked increase in marbling; Phander (1955) who found that the addition of grain to a roughage ration resulted in more marbling; and Matthews and Bennett (1962) who noted that fast-gaining steers yielded carcasses that contained more marbling than those that were fed to gain more slowly.

Conformation grades for the carcasses from the corn-fed steers in treatment 3 were significantly higher than for the corn and silage-fed steers in treatment 2 or the corn silage-fed steers in treatment 1 ($P < .01$). This indicates that the significant difference probably was due to the higher degree of finish on the corn-fed steers because the separable muscle of the round, previously discussed, indicated that there was essentially no difference in muscle development among treatments.

All carcasses were placed in the A maturity group which was expected since the steers in the three treatments were of similar age when slaughtered (Table IX).

Muscle color and firmness scores for the carcasses were significantly higher for the corn-fed steers in treatment 3 than for the other two treatments ($P < .05$). This indicated that the corn-fed steers, with the higher degree of finish, produced brighter and firmer muscles. Although there was a significant difference in muscle color and firmness scores between treatments, none of the treatments produced carcasses which were unacceptable in these respects. This agrees with

TABLE IX

LEAST SQUARE MEANS FOR GRADE FACTORS AND MUSCLE AND FAT CHARACTERISTICS

Item	Treatment 1	Treatment 2	Treatment 3
Marbling score[a,b]	3.7	3.9	4.7
Conformation grade[b,c]	10.5	11.2	11.1
Carcass grade[b,c]	9.3	9.9	11.1
Maturity grade[d]	2.1	2.1	2.2
Muscle color score[e]	5.0	4.7	5.6
Muscle texture score	3.8	3.9	4.3
Muscle firmness score[e]	3.9	4.0	4.6
Fat color score	2.4	2.2	2.4
Marbling texture score[f]	2.1	2.1	1.5

[a] 3=traces and 4=slight.

[b] Treatments 1 and 2 $<$ 3 ($P < .01$).

[c] 9=low good, 10=avg. good, 11=high good, 12=low choice and 13=avg. choice.

[d] 2=A and 3=A^+.

[e] Treatments 1 and 2 $<$ 3 ($P < .05$).

[f] Treatments 1 and 2 $>$ 3 ($P < .05$).

the work of Bray (1938) who found muscles darker and less desirable in grass-fattened steers than in steers that had been fattened on grain plus grass. He also found muscles to be slightly firmer in the grass-fattened steers.

Muscle texture score was not significantly different among the three treatments. This also agrees with the work of Bray (1938) who found texture to be slightly, but not significantly, finer in the grain and grass-fattened steers than in those steers that had been fattened on grass alone.

Fat color did not differ significantly among the three treatments. Marbling texture score was significantly lower (indicating coarser texture) for the corn-fed steers in treatment 3 than for the corn and corn silage fed steers in treatment 2 or the corn silage-fed steers in treatment 1 ($P < .01$).

III. CORRELATION AMONG TRAITS

The simple correlation coefficients computed on a within-treatment basis among all traits studied are given in Table X.

One noteworthy aspect of this experiment is a comparison of live ultrasonic fat estimates to actual fat thickness over the <u>l. dorsi</u> muscle obtained from the carcasses at slaughter. These correlation coefficients ranged from 0.56 ($P < .01$) at the first scan date to 0.83 ($P < .01$) at the fourth scan date approximately one month before slaughter. The accuracy in predicting carcass fat thickness improved

TABLE X

SIMPLE CORRELATION COEFFICIENTS AMONG CARCASS TRAITS[a, b]

	(46)	(45)	(44)	(43)	(42)	(41)	(40)	(39)	(38)	(37)	(36)	(35)	(34)	(33)	(32)	(31)	(30)	(29)	(28)	(27)	(26)	(25)	(24)	(23)	(22)	(21)	(20)	(19)	(18)	(17)	(16)	(15)	(14)	(13)	(12)	(11)	(10)	(9)	(8)	(7)	(6)	(5)	(4)	(3)	(2)
(1) Fat thickness est. 1-12-65	0.48	0.49	0.36	0.63	0.34	0.51	0.57	0.41	0.31	0.33	0.49	0.51	0.49	0.53	0.44	0.31	-.22	0.10	0.16	-.06	0.15	0.09	0.44	0.44	0.29	0.42	0.43	0.31	0.18	0.39	0.18	0.15	0.14	0.27	0.45	0.55	0.33	0.34	0.55	0.24	0.56	0.24	0.67	0.81	0.91
(2) Fat thickness est. 2-10-65	0.53	0.46	0.35	0.64	0.38	0.53	0.62	0.39	0.33	0.36	0.44	0.50	0.52	0.56	0.46	0.30	-.16	0.16	0.23	-.03	0.16	0.14	0.47	0.38	0.30	0.42	0.44	0.25	0.22	0.32	0.19	0.15	0.18	0.27	0.53	0.56	0.41	0.29	0.60	0.20	0.58	0.16	0.77	0.84	
(3) Fat thickness est. 3-9-65	0.51	0.52	0.25	0.62	0.32	0.35	0.49	0.30	0.11	0.23	0.30	0.44	0.43	0.49	0.37	0.19	-.23	-.20	0.23	-.06	0.08	0.01	0.48	0.20	0.14	0.31	0.33	0.02	0.18	0.17	0.08	-.03	-.02	0.17	0.45	0.53	0.28	0.36	0.46	0.08	0.65	0.03	0.82		
(4) Fat thickness est. 4-19-65	0.73	0.71	0.32	0.73	0.66	0.45	0.72	0.47	0.29	0.51	0.55	0.69	0.68	0.70	0.65	0.27	-.43	0.31	0.35	0.04	0.32	-.07	0.72	0.25	0.29	0.44	0.49	0.16	0.26	0.42	0.13	0.05	0.13	0.30	0.62	0.78	0.33	0.48	0.62	0.14	0.83	0.17			
(5) L. dorsi area	0.35	0.30	0.45	0.43	0.31	0.59	0.50	0.63	0.39	0.59	0.55	0.48	0.52	0.51	0.52	0.49	-.14	0.05	0.19	0.12	0.23	0.35	0.33	0.60	0.62	0.61	0.59	0.51	0.11	0.28	0.46	0.29	0.28	0.27	0.29	0.39	-.07	0.49	0.25	0.39	0.08				
(6) Fat thickness (act.)	0.82	0.66	0.40	0.67	0.71	0.47	0.66	0.57	0.33	0.54	0.59	0.71	0.71	0.72	0.68	0.31	-.49	0.13	0.24	0.05	0.31	-.02	0.80	0.34	0.35	0.51	0.56	0.21	0.17	0.37	0.18	0.11	0.15	0.34	0.51	0.75	0.38	0.41	0.56	0.15					
(7) Carcass length	0.45	0.48	0.41	0.31	0.44	0.66	0.55	0.49	0.62	0.67	0.54	0.53	0.57	0.55	0.58	0.45	-.08	-.08	0.23	0.16	0.42	0.31	0.29	0.44	0.59	0.54	0.53	0.44	0.24	0.46	0.53	0.52	0.56	0.49	0.32	0.39	-.09	0.13	0.21						
(8) Marbling score	0.67	0.49	0.41	0.57	0.69	0.49	0.63	0.54	0.48	0.56	0.66	0.71	0.65	0.62	0.67	0.17	-.22	0.22	0.29	-.11	0.22	-.08	0.66	0.28	0.33	0.44	0.48	0.26	0.27	0.35	0.17	0.07	0.12	0.29	0.91	0.60	0.39	0.39							
(9) Confo. grade	0.52	0.55	0.29	0.45	0.46	0.32	0.44	0.55	0.34	0.50	0.45	0.55	0.54	0.54	0.53	0.30	-.43	0.19	0.52	0.36	0.15	0.03	0.52	0.32	0.36	0.46	0.48	0.30	0.25	0.15	-.07	-.20	-.19	0.20	0.53	0.58	-.26								
(10) Maturity score	0.27	0.07	0.12	0.25	0.20	0.21	0.31	0.13	0.16	0.14	0.28	0.29	0.23	0.23	0.22	0.08	0.23	0.14	-.08	-.20	0.27	-.06	0.24	0.10	0.06	0.13	0.16	0.05	-.03	0.22	0.21	0.19	0.23	0.08	0.18	0.10									
(11) Est. kidney fat	0.84	0.77	0.51	0.83	0.79	0.63	0.82	0.70	0.51	0.71	0.71	0.77	0.84	0.85	0.81	0.48	-.55	0.26	0.16	0.00	0.35	0.20	0.83	0.49	0.57	0.67	0.72	0.44	0.28	0.58	0.31	0.25	0.31	0.45	0.57										
(12) Carcass grade	0.69	0.57	0.39	0.55	0.68	0.51	0.61	0.53	0.48	0.58	0.61	0.71	0.66	0.63	0.68	0.11	-.22	0.11	0.53	0.14	0.29	-.10	0.67	0.18	0.31	0.42	0.46	0.17	0.34	0.24	0.12	-.03	0.04	0.25											
(13) Rump length	0.52	0.36	0.39	0.44	0.52	0.57	0.61	0.65	0.29	0.61	0.58	0.57	0.62	0.61	0.60	0.60	-.29	0.07	0.13	-.02	0.32	0.39	0.41	0.61	0.65	0.67	0.66	0.31	0.20	0.43	0.60	0.58	0.55												
(14) Hock to hip length	0.43	0.26	0.61	0.43	0.45	0.65	0.58	0.52	0.37	0.51	0.52	0.44	0.54	0.55	0.52	0.72	0.01	0.09	-.22	-.30	0.22	0.58	0.27	0.54	0.69	0.62	0.61	0.54	0.11	0.57	0.80	0.97													
(15) Ext. leg length	0.37	0.19	0.57	0.38	0.37	0.63	0.52	0.51	0.31	0.45	0.48	0.37	0.48	0.50	0.46	0.74	-.01	0.01	-.21	-.33	0.17	0.66	0.21	0.58	0.67	0.62	0.60	0.55	0.16	0.53	0.86														
(16) Int. leg length	0.46	0.27	0.56	0.44	0.44	0.70	0.57	0.67	0.38	0.61	0.54	0.47	0.59	0.61	0.57	0.71	-.05	-.04	-.08	-.31	0.20	0.65	0.37	0.71	0.75	0.74	0.73	0.49	0.22	0.46															
(17) Loin length	0.46	0.45	0.47	0.50	0.54	0.49	0.61	0.48	0.40	0.57	0.59	0.55	0.58	0.56	0.60	0.46	-.20	0.26	-.01	-.18	0.13	0.07	0.39	0.45	0.52	0.48	0.49	0.62	0.23																
(18) Fat over biceps fem.	0.33	0.35	0.11	0.21	0.37	0.29	0.31	0.30	0.15	0.34	0.30	0.37	0.36	0.36	0.35	0.13	-.35	0.12	0.38	0.00	0.20	0.08	0.37	0.09	0.13	0.28	0.31	0.15																	
(19) Biceps fem. area	0.34	0.27	0.60	0.44	0.38	0.53	0.48	0.63	0.51	0.53	0.55	0.44	0.52	0.50	0.52	0.64	0.00	0.10	0.10	-.04	0.11	0.42	0.27	0.75	0.73	0.67	0.63																		
(20) Untrimmed round wt.	0.80	0.62	0.58	0.74	0.78	0.83	0.83	0.96	0.60	0.87	0.85	0.83	0.92	0.93	0.90	0.84	-.28	0.14	0.14	-.10	0.30	0.60	0.78	0.83	0.90	0.99																			
(21) Trimmed round wt.	0.75	0.56	0.76	0.70	0.73	0.82	0.79	0.96	0.59	0.84	0.84	0.79	0.88	0.89	0.86	0.86	-.24	0.13	0.13	-.11	0.28	0.63	0.72	0.87	0.92																				
(22) Biceps fem. wt.	0.63	0.46	0.72	0.63	0.61	0.80	0.71	0.90	0.52	0.78	0.73	0.67	0.78	0.78	0.76	0.77	-.14	0.13	0.06	-.03	0.27	0.57	0.53	0.88																					
(23) Round sep. mus. wt.	0.48	0.31	0.60	0.57	0.44	0.72	0.60	0.85	0.47	0.64	0.66	0.55	0.65	0.66	0.62	0.72	-.15	0.05	0.02	-.08	0.18	0.58	0.46																						
(24) Round sep. fat.wt.	0.90	0.70	0.56	0.77	0.88	0.62	0.76	0.77	0.48	0.73	0.78	0.84	0.87	0.86	0.86	0.47	-.50	0.16	0.19	-.11	0.33	0.17																							
(25) Round sep. bone wt.	0.23	0.09	0.49	0.24	0.17	0.49	0.35	0.48	0.34	0.35	0.30	0.20	0.35	0.40	0.30	0.74	0.07	-.14	-.14	-.17	0.04																								
(26) Muscle color	0.37	0.37	-.10	0.17	0.37	0.36	0.37	0.33	0.47	0.43	0.44	0.46	0.39	0.37	0.39	0.14	-.15	-.07	0.44	0.44																									
(27) Muscle texture	0.02	0.09	-.33	-.14	-.12	-.02	-.06	-.01	0.12	0.05	-.13	-.02	-.05	-.04	-.06	-.28	-.11	-.28	0.70																										
(28) Muscle firmness	0.26	0.33	-.07	0.05	0.21	0.12	0.17	0.23	0.21	0.29	0.19	0.33	0.24	0.23	0.25	-.05	-.15	-.15																											
(29) Fat color	0.15	0.15	0.04	0.17	0.20	0.06	0.24	0.16	-.03	0.13	0.18	0.22	0.19	0.19	0.18	0.06	-.08																												
(30) Marb. texture	-.50	-.45	-.07	-.41	-.48	-.15	-.29	-.31	-.02	-.29	-.24	-.38	-.40	-.40	-.39	-.05																													
(31) Hind shank wt.	0.51	0.40	0.75	0.51	0.55	0.64	0.66	0.72	0.50	0.67	0.70	0.61	0.70	0.70	0.67																														
(32) Forequarter wt.	0.90	0.78	0.69	0.75	0.94	0.77	0.89	0.88	0.68	0.95	0.92	0.96	0.99	0.96																															
(33) Hindquarter wt.	0.94	0.81	0.70	0.82	0.88	0.83	0.95	0.89	0.61	0.89	0.88	0.93	0.99																																
(34) Side wt.	0.93	0.80	0.70	0.79	0.92	0.81	0.93	0.89	0.65	0.93	0.91	0.95																																	
(35) Rib wt.	0.88	0.81	0.63	0.70	0.92	0.70	0.86	0.82	0.60	0.87	0.95																																		
(36) Rib cuts wt.	0.78	0.68	0.70	0.66	0.85	0.74	0.84	0.84	0.62	0.84																																			
(37) Chuck wt.	0.78	0.67	0.58	0.58	0.84	0.77	0.84	0.85	0.78																																				
(38) Chuck cuts wt.	0.50	0.42	0.34	0.31	0.57	0.63	0.64	0.57																																					
(39) Round cuts wt.	0.78	0.58	0.70	0.72	0.76	0.80	0.77																																						
(40) Loin wt.	0.86	0.71	0.64	0.77	0.79	0.86																																							
(41) Loin cuts wt.	0.74	0.51	0.69	0.71	0.58																																								
(42) Plate wt.	0.88	0.78	0.59	0.68																																									
(43) Brisket wt.	0.80	0.68	0.71																																										
(44) Foreshank wt.	0.62	0.48																																											
(45) Kidney knob wt.	0.79																																												
(46) Flank wt.																																													

[a]Values of 0.35 and 0.45 required for significance at the 0.05 and 0.01 levels respectively.

[b]Calculated on a within-treatment basis.

with each successive scan. This indicates that live fat estimates obtained with the Model 52 ultrasonic instrument and actual fat thickness over the l. dorsi muscle were closely associated and that live ultrasonic estimates of fat thickness may be used as guides to the actual fat thickness of an animal.

The associations between actual fat thickness and weights of the untrimmed wholesale cuts from the forequarter were highly significant with the exception of foreshank weight which was significant at the 5 per cent level of probability. Correlation coefficients of 0.71, 0.54, 0.71, 0.67 and 0.40 were found between actual fat thickness and rib, chuck, plate, brisket and foreshank weights, respectively.

Significant associations also were noted between actual fat thickness and weight of the wholesale cuts from the hindquarter. Correlation coefficients of 0.82, 0.66, 0.66 and 0.44 were found between actual fat thickness and flank, kidney knob, loin and untrimmed round weights, respectively. These coefficients, as well as those between actual fat thickness and weight of the cuts from the forequarter, indicate that the fatter carcasses produced heavier wholesale cuts. However, the association between actual fat thickness and side weight ($r = 0.71$) shows that the fatter carcasses also were heavier.

The correlation between actual fat thickness and round separable muscle weight approached significance at the 5 per cent level. Fat thickness was associated with 64 per cent of the variation in round separable fat weight. These results support the indication that the fatter animals required more trimming of the round although they did not yield significantly more total pounds of trimmed round than the animals that had the lesser degree of finish.

Actual fat thickness was not significantly correlated with muscle characteristics of color ($r = 0.31$), texture ($r = 0.05$) or firmness ($r = 0.24$), but was negatively correlated ($P < .01$) with marbling texture ($r = -.49$). These coefficients indicate that fat thickness was not a reliable predicator of muscle color, texture and firmness, and that as the fat thickness increased, marbling texture became coarser and less desirable.

Highly significant associations were observed between carcass length and the various hindquarter measurements. Correlation coefficients of 0.49, 0.56, 0.52 and 0.53 were found between carcass length and rump, hock to hip, external leg and internal leg lengths, respectively. Thus the longer carcasses tended to also have more length in these hindquarter measurements.

Fat over the biceps femoris muscle was associated with less than 14 per cent of the variation in retail cuts weight from the round, loin, rib and chuck. This indicates that fat over the biceps femoris muscle was not a good predictor of the weight of these cuts.

Area of the biceps femoris muscle was significantly correlated ($P < .01$) with biceps femoris weight ($r = 0.73$), round separable muscle weight ($r = 0.88$), and round cuts weight ($r = 0.90$). The correlation coefficient between area of biceps femoris muscle and round separable muscle weight indicates that the area of biceps femoris muscle may be useful in predicting round separable muscle in a beef carcass. This is in agreement with the findings of Williams (1965) who reported a correlation coefficient of 0.82 between these two variables.

Correlation coefficients of 0.55, 0.59 and 0.59 were noted between area of the l. dorsi muscle and rib, loin, round and chuck cuts weight, respectively. However, on a side weight constant basis, the association between l. dorsi area and the weights of these cuts was much lower (Table XI). This indicates that l. dorsi area was a poor predictor of the weight of these cuts.

Correlation coefficients that were highly significant were noted between untrimmed round weight and trimmed retail cuts weight from the round ($r = 0.96$), rib ($r = 0.85$), loin ($r = 0.83$) and chuck ($r = 0.60$). Also, trimmed round weight was highly significantly correlated with the weight of the retail cuts from the round ($r = 0.96$), rib ($r = 0.84$), loin ($r = 0.82$) and chuck ($r = 0.59$). This indicated that the weight of the round was an excellent predicator of the weight of these retail cuts and that little difference existed between the predictive value of the trimmed and untrimmed round.

Correlation coefficients of 0.65 ($P < .01$), 0.66 ($P < .01$) and 0.55 ($P < .01$) were found between round separable muscle weight and side weight, hindquarter weight, and forequarter weight, respectively. Thus the heavier animals tended to yield more total pounds of round separable muscle than the smaller animals. However, the correlation coefficients between round separable fat weight and side weight,

TABLE XI

SIMPLE CORRELATION COEFFICIENTS AND STANDARD PARTIAL REGRESSION COEFFICIENTS OF CERTAIN CARCASS MEASUREMENTS WITH TRIMMED ROUND WEIGHT, ROUND SEPARABLE MUSCLE WEIGHT, SIDE WEIGHT, ROUND CUTS WEIGHT AND ACTUAL FAT THICKNESS

Y	r^a or b'^b	X				
		Trimmed round weight	Round separable muscle weight	Side weight	Round cuts weight	Actual fat thickness
L. dorsi area	r	0.61	0.60	0.52	0.63	0.08
	b'	0.38	0.40	-	0.43	-
Biceps femoris area	r	0.67	0.75	0.52	0.63	0.21
	b'	0.53	0.57	-	0.43	-
Hock to hip length	r	0.62	0.54	0.54	0.52	0.15
	b'	-	0.30	-	-	-

[a]Simple correlation coefficients; P < .05=0.35 and P < .01=0.45.

[b]Standard partial regression coefficients with side weight held constant.

hindquarter weight, and forequarter weight were considerably higher. Thus, increases in side weight appeared to be primarily fat.

Conformation grade was positively associated ($r = 0.51$) with fat thickness, indicating that the federal grader tended to give higher conformation grades to the fatter animals.

A correlation of 0.09 was found between round separable muscle weight and fat over the biceps femoris muscle, indicating that fat thickness over the biceps femoris muscle was not an accurate predictor of round muscle weight.

A highly significant correlation of 0.61 was found between area of the l. dorsi muscle and trimmed round weight. However, on a side weight constant basis, the association between these two variables was only 0.38 ($P < .05$). This indicated that the area of the l. dorsi muscle was not an efficient predictor of trimmed round weight. This indication is supported by the standard partial regression coefficients between area of the l. dorsi muscle and round separable muscle weight and area of the l. dorsi muscle and round retail cuts weight--each on a side weight constant basis (Table XI, page 50).

Area of the biceps femoris muscle was significantly associated with the weight of the untrimmed round, round separable muscle weight and rounds cuts weight. On a side weight constant basis, these associations were also significant, indicating that the area of the biceps femoris muscle shows promise as a predictor of the weights of these cuts. Likewise, the area of the biceps femoris muscle was an excellent predictor of round separable muscle weight when fat thickness was held constant (b' = 0.95). Variation in the area of the biceps femoris muscle accounted for over 90 per cent of the variation in round separable muscle weight when these variables were compared on a fat thickness constant basis.

CHAPTER V

SUMMARY

An experiment involving 36 Hereford steers was conducted to determine the effect of three controlled levels of fatness upon production and carcass characteristics and to determine the level of fatness which would produce the highest yield of trimmed retail cuts but still maintain acceptable meat quality in beef steers of similar age.

Three rations were formulated to produce from 3 to 5, 8 to 10, and 13 to 15 mm. of fat thickness over the longissimus dorsi muscle in the 12th-13th rib region in treatments 1, 2 and 3, respectively. The steers were put on feed December 15, 1964. Fat thickness estimates were obtained with a Branson Sonoray Model 52 ultrasonic instrument to determine the amount of progress each steer was making toward its desired level and to determine a slaughter date for the three treatments. Hot carcass weight, carcass length, actual fat thickness, conformation grade, carcass grade, maturity, marbling score, l. dorsi muscle area and estimated kidney, pelvic and heart fat data were obtained. The left side of each carcass was cut into wholesale and partially boneless, trimmed retail cuts to obtain carcass yield data.

The results were as follows:

1. Treatment 3 steers, which gained 1.93 lb. per day, began an accelerated fattening phase on or near the third ultrasonic scan

date (March 9, 1965). Treatment 2 steers, which gained 1.38 lb. per day, began their fattening phase approximately 40 days later; and treatment 1 steers, which gained 1.14 lb. per day, showed little change in rate of fat deposition throughout the experimental feeding period of 150 days which ended in May, 1965.

2. There was no significant difference in feed cost per hundredweight gain among the three treatments.

3. Rib eye area, on a per cent of carcass basis, was significantly larger for treatment 1 than for treatments 2 and 3 ($P < .05$).

4. Forequarter and hindquarter weights were significantly different ($P < .01$) among treatments with the faster-gaining groups having heavier weights. However, on a per cent of side weight basis, no significant difference was found among the three treatments.

5. Separable muscle and bone from the round was not significantly different among the three treatments. However, separable fat significantly ($P < .01$) favored the steers in treatment 3.

6. No significant differences were observed in carcass length, leg length and rump length measurements among the three treatments.

7. Marbling score significantly ($P < .01$) favored the steers in treatment 3 as did muscle color ($P < .05$) and muscle firmness ($P < .05$). Differences between treatments 1 and 2 were not significant.

8. Estimated fat thickness became more closely associated with actual fat thickness with each successive scan. The last ultrasonic estimate, approximately one month before slaughter, was associated

with over 68 per cent of the variation in actual fat thickness. Area of the biceps femoris muscle was associated with over 77 per cent of the variation in round separable muscle weight, yet fat thickness over the biceps femoris muscle was associated with less than 1 per cent of the variation in round separable muscle weight.

9. With actual fat thickness held constant, area of the biceps femoris muscle was associated with over 89 per cent of the variation in round separable muscle.

Ration had no apparent effect upon the muscular and skeletal development of the carcasses in the three treatments as shown by round cut-out and skeletal measurements. Although the faster-gaining animals had carcasses that weighed significantly ($P < .01$) more than those of the slower-gaining animals, this difference may be attributed to the greater amount of fat deposition in the faster-gaining animals. The rate of fat deposition was different among treatments with the faster-gaining groups depositing fat at an increased rate. This trend was especially apparent toward the end of the 150-day feeding period.

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