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The effects of subcutaneous fat thickness on the production efficiency and organopeltic properties of beef

William R. Backus

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To the Graduate Council:

I am submitting herewith a dissertation written by William R. Backus entitled "The effects of subcutaneous fat thickness on the production efficiency and organopeltic properties of beef." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Animal Science.

C. S. Hobbs, Major Professor

We have read this dissertation and recommend its acceptance:

J. W. Cole, C. B. Ramsey, M. R. Johnston, W. W. Overcast

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

May 13, 1968

To the Graduate Council:

I am submitting herewith a dissertation written by William Robert Backus entitled "The Effects of Subcutaneous Fat Thickness on the Production Efficiency and Organoleptic Properties of Beef." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Animal Science.

Charles S Hobbs
Major Professor

We have read this dissertation
and recommend its acceptance:

J M Cole

C B Ramsey

M R Johnston

W W Overcast

Accepted for the Council:

Hilton A. Smith
Vice President for
Graduate Studies and Research

THE EFFECTS OF SUBCUTANEOUS FAT THICKNESS ON THE PRODUCTION EFFICIENCY AND ORGANOPELTIC PROPERTIES OF BEEF

A Dissertation
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

by
William Robert Backus
June 1968

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ABSTRACT

Eighty-four weanling Hereford steers were used in a two-year study of the effects of three pre-determined subcutaneous fat thickness levels on the production efficiency and organoleptic properties of beef. Three rations (low, medium and high energy levels) were fed to produce a fat thickness over the 12th - 13th rib of 5 mm., 8 to 10 mm. and 13 to 15 mm. for the three rations respectively, after a 150 to 185 day feeding period. Average daily gains were 1.18 lb., 1.55 lb. and 2.07 lb. The rate of fat deposition was monitored by ultrasonic means.

Carcass conformation grade, marbling score and carcass grade were significantly ($P<.01$) increased as level of energy in the ration increased. Higher feeding levels tended to produce brighter colored, firmer, finer textured muscle. Ration had no significant effect on flavor and juiciness scores. A tendency for tenderness to decrease as feeding level increased was observed. Carcasses from steers on the highest energy level had significantly ($P<.01$) lower tenderness scores and higher shear values. Significant ($P<.01$) negative relationships were found between tenderness and marbling score ($r = -.35$) carcass grade ($r = -.40$) and fat thickness ($r = -.41$). Ultrasonic estimates of fat thickness and carcass fat thickness were highly related.

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CHAPTER I

INTRODUCTION

Cattle are highly prized for their ability to produce succulent, nutritious muscle. Beef accounts for the greatest percentage of "red meat" consumed in the United States. It is considered a prestige food.

Varying periods of moderate to high concentrate feeding are used in traditional beef production methods. These systems of production often result in the production of excess adipose tissue in the carcass. However, this fattening is thought to be necessary since it is assumed that the palatability of the beef is increased.

Fat is a surplus, low monetary value commodity in the United States. Beef cuts with excess fat must be closely trimmed before being sold. The trimming of fat from beef retail cuts must result in higher prices to provide adequate merchandising margins. Therefore, carcasses with excess fat are discriminated against in the meat trade.

In the near future, a rapidly increasing world population could be in direct competition with meat animals for the available feed grains. This scarcity could make the cost of feeding large amounts of concentrates prohibitive. Beef cattle would be invaluable in this situation because of their inherent ability to convert roughage and certain concentrate feeds not useable for humans to high quality protein.

The objectives of the research reported herein were:

1. To determine the effect of three subcutaneous fat levels on flavor, juiciness and tenderness of beef.

2. To evaluate the effect of fatness on dressing percentage, cutability, grade and other factors used to assess the value of live cattle and their carcasses.

3. To examine the relative muscular and skeletal development of cattle fed to three prescribed fat levels.

CHAPTER II

REVIEW OF LITERATURE

Research efforts dealing with the relationship between measures of fatness in the beef carcass and its subsequent palatability have been rather extensive. Some of the early work, although well designed and executed, cannot relate totally to the market cattle population of today since the genetic background, age and market weight of the cattle were drastically different. These factors have been shown to affect palatability. Recent studies have raised serious questions pertaining to the factors which presently are given major emphasis in grading beef carcasses. There is a paucity of information dealing with the optimum fatness of the bovine to maximize both palatability and cutability.

I. PALATABILITY

Mumford (1902) stated that the quality of beef depends largely upon the degree of fatness of the animal. He gave three principal reasons for fattening a steer:

> (a) In order that when dressed there will not be a high percentage of offal and other waste, as a fat animal, other things being equal, will dress a higher percentage of carcass than a half fat or a thin one, and furthermore in the fat animal the proportion of those parts, which from their very nature are unsalable, is reduced to a minimum;
>
> (b) in order that the flesh or lean meat shall be rendered more tender, juicy and of better flavor by the deposition of fat throughout its substance;

> (c) in order to permit of proper ripening of the meat, as a thin carcass being full of moisture and lacking the protection of a covering of fat, will rot before it will ripen.

He further stated that the possibility of securing the highest quality in beef is influenced by the breeding and general quality of the animal.

Kiehl and Rhodes (1960) credited Alvin H. Sanders, editor of the Breeder's Gazette, as the leader of a long and fervent campaign to initiate the grading of beef. Sanders wished to promote an increased demand for well-bred and well-fed beef which would increase the demand for purebred beef cattle. He chose to dramatize the alleged inferior eating qualities of leaner beef with the terms "tiger-meat" or "cat meat." It seems probable that his campaign did much to develop and solidify popular ideas of the relationship between beef palatability and factors like breeding and degree of fatness. Sanders stated that the lesson the public needs to learn is that lean beef is necessarily poor beef.

Kiehl and Rhodes (1960) related that, in 1926, W. C. Davis of the United States Department of Agriculture Bureau of Agricultural Economics wrote that, "Consumers must learn the lesson that very lean beef is always tough beef, and the muscular tissues of animals are made tender and fully flavored by the presence of plenty of fat."

Briskey and Bray (1964) concluded that the first U. S. D. A. carcass grades for beef were based on opinion and experience, since little or no research was available relating carcass traits to carcass value when the first standards were published in 1923. Scott (1939) stated that fat should be looked upon as a necessary evil in producing the better grades of beef. He concluded that the amount of fat should be kept to a minimum consistent with getting the two important consumer factors, i. e., tenderness and flavor. He further stated that, if the average consumer could get tender beef with some flavor and with very little fat, he would be well pleased.

Hankins and Ellis (1939) used a group of 728 cattle which varied widely to study fatness in relation to quantity and quality factors of beef carcasses. A low correlation (r = -.11) was found between percentage of fat (ether extract) in the longissimus dorsi (l. dorsi) muscle of the 9-10-11 rib section and tenderness of the same muscle. The percentage of ether extract in the edible portion of the 9-10-11 rib section and tenderness of the l. dorsi muscle had a simple correlation coefficient of -.22. A second group of 69 cattle, which varied in age from 9 to 18 months and had been fed grain and roughage in dry lot, yielded a simple correlation coefficient of -.07 between the ether extract content and tenderness of the l. dorsi muscle. These workers concluded that variations in tenderness were caused mainly by factors other than fatness.

Barbella et al. (1939) used 728 heifer and steer cattle, ranging in weight from 250 to 1,580 pounds and in age from 8 to 42 months, to study the relationships of flavor and juiciness of beef to fatness and other factors. They found small but statistically significant associations between degree of fatness and desirability and intensity of flavor of lean, desirability and intensity of flavor of fat and quality (richness) and quantity of juice.

Wanderstock and Miller (1948) used yearling steers from three feeding trials to study the effects of method of feeding on quality and palatability of beef. Treatments were pasture only, feeding grain while on pasture and feeding grain while in dry lot. The steers receiving no grain had significantly lower final live grades, dressing percentages and carcass grades than those on the other treatments. All of the beef was acceptable although carcass grades varied widely.

Jacobson and Fenton (1956) studied the effects of three levels of nutrition on the quality of beef from the Holstein breed of dairy cattle. Cattle were fed 60, 100 and 160 percent of the upper limits of Morrison's (1947) standards for growing dairy heifers. It was found that, as level of nutrition increased, the weight of the muscles and fat increased. No consistent effects of level of nutrition on shear value, aroma or juiciness of the meat were shown. Tenderness of the _l. dorsi_ muscle may have been improved. The flavor of the beef from animals on the higher levels of nutrition was preferred over that of beef from animals on the low level.

Doty and Pierce (1961) found that tenderness of unaged meat was closely correlated with intramuscular fat content as determined by both chemical means and marbling score. Juiciness of broiled steaks was closely associated with fat content. These workers found some indication that the relationship between intramuscular fat and juiciness was not apparent above an intramuscular fat level of about 7 to 8 percent. Lean flavor was shown to not be significantly associated with any other property of meat evaluated.

Rogers et al. (1966) stated that, although the ability of marbling to predict palatability of meat is not necessarily high, the relationship appears to be positive. Shear values of cooked rib steaks indicated that those with a devoid marbling score were less tender than those with traces of marbling. Steaks with these two degrees of marbling were significantly less tender than those having slight, small, modest moderate or slightly abundant marbling scores.

Wellington and Stouffer (1959) used 121 beef cattle of widely varying fatness and marbling to study the influence of marbling on tenderness and juiciness. The differences in tenderness as measured by mechanical shear resistance of cooked l. dorsi steaks were not significant. However, an experienced sensory panel found that increased tenderness was positively related to more abundant marbling. The tenderness differences associated with marbling accounted for only 7 percent of the tenderness variance. The panel also found a significant increase in the juiciness of the beef as the degree of marbling increased.

Kidwell et al. (1959) observed no significant association between tenderness score and either fatness, average daily gain or any other preference measure. Flavor of muscle was positively associated with percent fat, average daily gain and quality of juice. Quality of juice was more dependent on muscle constituents than on fatness.

Wheat and Holland (1960) calculated a correlation coefficient between carcass grade and marbling score of 0.89 from data of 688 Hereford heifer and steer carcasses. Suess et al. (1966) found that grade, marbling score and bone maturity, whether considered simultaneously or singly, were associated with less than 7 percent of the variation in semimembranosus or l. dorsi muscle tenderness. These same variables were associated with less than 11 percent of the variation in juiciness of either muscle. Standardized partial regression coefficients indicated that length of test period exerted the greatest influence upon l. dorsi tenderness. Retail yield per day of age, age and length of test period exerted the greatest influence upon l. dorsi tenderness. Retail yield per day of age, age and length of test period had the greater influences upon semimembranosus tenderness.

Cover and Hostetler (1960) used two muscles, l. dorsi and biceps femoris (b. femoris) from 91 steers to evaluate tenderness by new methods. The three components of tenderness studied were connective tissue, crumbliness of muscle fibers and softness. Carcass grade and marbling were not consistently nor closely related to measures of tenderness of connective tissue or of muscle fibers. Carcass grade and marbling were shown to not be as valuable for selecting either moist or dry heat methods of cooking as was formerly supposed.

Cover et al. (1956) studied the relationship of fatness in yearling steers to juiciness and tenderness of broiled and braised steaks. Forty-seven Hereford and 50 Brahman X Hereford steers were used. Fatness was measured by physical separation, by estimated marbling and by percentage ether extract of trimmed muscles. Juiciness scores were shown to be more closely correlated with fatness in broiled l. dorsi than in braised l. dorsi or in broiled or braised b. femoris. Juiciness scores were more closely correlated with ether extract than with other measures of fatness. Fatness seemed more closely related to tenderness scores in the bottom round muscle than in the loin muscle. Tenderness scores were more closely correlated with ether extract than with other measures of fatness. Variations in fatness of loin steaks cooked by broiling, at best, accounted for about 10 percent of the variation in tenderness and about 25 percent of the variation in juiciness. Fatness of the braised bottom round muscle accounted for about 30 percent of the variation in tenderness and about 5 percent of the variation in juiciness.

Tuma _et_ _al_. (1962) found that marbling had more influence on tenderness in certain maturity groups than in others. Pilkington _et_ _al_. (1960) showed that the fat content of beef ribs was positively associated with tenderness.

Walter _et_ _al_. (1965) selected 72 beef carcasses representing three maturity groups (A, B and F) and six marbling scores (practically devoid through moderately abundant) to study the effect of marbling and maturity on beef tenderness. Marbling did not exert a significant effect on tenderness, flavor or juiciness scores. Tenderness and juiciness decreased with advancing maturity which was determined by muscle and bone characteristics.

Little _et_ _al_. (1966) fed yearling Angus steers for 28, 56, 84 and 112 days. Flavor, juiciness and overall satisfaction scores of the meat from the steers in the four feeding periods were significantly different. No pattern was indicated for the effect of length of feeding period on flavor, juiciness or overall satisfaction. No significant difference was found in the tenderness of the l. dorsi muscle from the 6-7-8 rib cut of cattle from any group when measured by taste panel or Warner-Bratzler shear value.

Romans et al. (1965) selected 80 beef ribs representing four maturity levels (A, B, C and D) and two marbling levels (slight and moderate) to investigate the effects of maturity and marbling on palatability. Neither marbling nor maturity had a significant effect on tenderness as determined by the Warner-Bratzler shear value. Steaks from the l. dorsi of the more mature carcasses generally were considered less tender than those from less mature carcasses by a taste panel. The taste panel could not detect differences in tenderness due to marbling or sample location. The flavor of steaks from the less mature carcasses generally was preferred. Steaks containing a moderate amount of marbling were significantly more juicy than those containing a slight amount.

Sliger (1966) used 138 beef females ranging in age from 3 to 211 months to study the influence of chronological age on carcass composition, meat characteristics and palatability. He observed that the muscle from animals slaughtered between the ages of 12 and 17 months was less tender than at all other ages under approximately 42 months. The simple correlation coefficients between marbling score and shear values (r = -.01) and sensory panel tenderness scores (r = -.13) were not significant. Marbling score was significantly associated with panel juiciness (r = 0.48) and flavor scores (r = 0.36).

Blumer (1963) extensively reviewed the literature dealing with marbling of beef. He stated that the results of studies relating marbling with tenderness, flavor and juiciness have caused some pause for reflection as to whether or not marbling should receive such great emphasis in the projection of raw beef characteristics to eating satisfaction in the cooked meat. Pearson (1966) hinted that there may be some mechanical advantage to increased marbling if fat and its supporting connective tissue are more tender than muscle.

Brady (1937) used six Hereford and Shorthorn yearling steers and seven mature, grade Holstein cows to study the factors influencing the tenderness and texture of beef. Significant differences in diameter of muscle fibers and size of muscle bundles were found in the two classes of beef. It was concluded that texture is dependent on size of muscle bundle. Larger bundles were associated with finer texture. Texture was implicated as an indicator of tenderness since finer-textured meat was more tender.

Hendrickson and Moore (1965) showed that broiled steaks from 18-month-old cattle were more tender than those from cattle 6, 42 or 90 months of age. Steaks from the _l. dorsi_ were slightly more tender than those from the _semitendinosus_. Steaks with a high level of intramuscular fat were more tender than those with a low level of fat. However, the amount of fat within the muscle was relatively unimportant in steaks from animals under 20 months of age. Intramuscular fat was more important in determining the tenderness, juiciness and flavor of steaks from older cattle.

Brady (1957) concluded that most consumers knew very little about beef quality or grades. Consumer dissatisfaction with beef related mostly to tenderness. There was a general aversion to fat. The consumer wanted an impossible combination of leanness, juiciness, tenderness and flavor. It was admitted that this is difficult but not impossible to accomplish.

Pilkington *et al*. (1960) studied the firmness of beef rib steaks as related to tenderness and fat content. A simple correlation coefficient of 0.90 was obtained between firmness and fat content. Positive simple correlation coefficients between firmness and tenderness were found. Partial regression coefficients indicated that, when fat content was held constant, the softer rib steaks tended to be more tender than the firmer rib steaks.

Cole *et al*. (1960a) showed that palatability scores were positively associated with carcass grade. This work tends to agree with the findings of Black *et al*. (1931) and Husaini *et al*. (1950a). It agrees also with the work of Armsby (1908, 1917), Bull (1916), Hall (1910), Helser (1929) and Henry and Morrison (1916), who expressed the belief that the fattening of the animal increases juiciness and tenderness.

Cole *et al*. (1964) reported the results of a study involving Angus, Hereford, Jersey, Holstein, Brahman, Brahman crossbred and Charolais steers. Angus carcasses graded highest of all but had low cutting yields, largely due to a higher percent fat. Hereford carcasses had higher cutting yields and were rated slightly higher than Angus on palatability despite a significantly lower carcass grade and degree of marbling. Jersey steaks and roasts were scored among the most tender, but differences between Jerseys and Herefords were not always significant. Holstein steers had the highest daily gains with the highest feed efficiency and produced carcasses with high cutting yields. They were average among the breeds in eating quality. Brahmans had a high percent of separable muscle but had poor feed lot performance and ranked last on palatability scores. The Charolais were fast gainers, were very efficient in feed utilization, had high dressed yields and were low in waste fat, but they were relatively low in marbling score and carcass grade. Their palatability was average for the other breeds studied.

II. CARCASS CUTABILITY

Murphey *et al*. (1960) reported the results of studies which were designed to develop a method for predicting the cutability of cattle. A correlation coefficient of 0.92 was found between the estimated and actual percent of bone-in trimmed retail cuts from the round, loin, rib and chuck when a subjective evaluation of exterior and kidney fat was used as the criterion for estimation. These workers reported a prediction equation for estimating the percent boneless, closely trimmed retail cuts in the round, loin, rib and chuck. Factors in the regression equation were fat thickness over the *l. dorsi* muscle, carcass weight, percent of the carcass in kidney, pelvic and heart fat and area of the *l. dorsi* muscle.

Tyler et al. (1964) studied the effects of variations in conformation on cutability of 40 beef carcass sides. These sides were as similar as possible in yield of boneless, trimmed retail cuts but widely different in conformation. The average quality grade of both groups was average Choice. Each group had a yield grade of 3. The high conformation group averaged high Choice in conformation while the low conformation group averaged low Good. Practically no difference was found between groups in the combined yield of boneless cuts from the round, loin, rib and chuck. The high conformation group had a larger area of l. dorsi muscle, thicker outside fat and less kidney fat. High conformation carcasses had greater fat yields but lower yields of bone. It was concluded that, at the same fat thickness, thickly muscled, high conformation cattle had higher cutability than thinly muscled cattle.

Goll et al. (1961a) examined the relationships between certain carcass measurements and yields of wholesale cuts. Correlation coefficients between 19 variables and weight and grade demonstrated that weight was more closely correlated with the yields of wholesale cuts than grade. The yields of round and chuck were negatively related to grade, whereas, the yields of rib and loin were positively related. Very few measurements or yields were closely related to l. dorsi muscle area. There was no clear evidence that l. dorsi area was closely related to items representing overall carcass value.

Henderson et al. (1966) found generally low correlations between l. dorsi area and percent carcass lean. However, high correlation coefficients were found between various round measurements and carcass yield. It was suggested that round measurements might be useful in predicting carcass muscling. The high negative relationship between fat thickness and carcass yield emphasized that fat thickness was very important in the determination of carcass yields.

Goll et al. (1961b) examined the influence of carcass grade and weight on the yield of wholesale cuts. The analyses showed that finish exerted more influence on yields of wholesale cuts than conformation.

Butler (1957) reviewed the relationship of conformation to carcass traits. He concluded that the animal breeder has considerable latitude in selecting animals of different shapes without encountering great changes in the proportion of wholesale cuts. It was emphasized that the cattle breeder should give increased emphasis to production efficiency, and that carcass shape may become less important to consumers when cuts are merchandised in trimmed, boneless form.

Kidwell et al. (1959) found that higher-grading feeder steers produced carcasses with a lower proportion of muscle and a higher proportion of fat. Little relationship was shown between feeder grade and subsequent rate or economy of gain. Carcass grade was largely a function of percent of fat in the carcass. Higher grading carcasses yielded more fat, less bone and muscle, a higher percent of loin, rib and plate and a lower percent of round and chuck. Carcass value was positively associated with carcass grade, dressing percent, percent loin, rib plate and fat and was negatively related to percent bone, muscle, round and chuck.

Cole *et al.* (1960b) evaluated the area of the *l. dorsi* muscle, carcass weight, the separable lean of a particular cut and various linear carcass measurements for their usefulness in predicting total carcass leanness. The area of the *l. dorsi* was associated with only 18 percent of the variation in separable carcass lean and 5 to 30 percent of the variation in the separable lean of the more valuable cuts of beef. Likewise, the relationships of the various linear carcass measurements with either *l. dorsi* area or carcass separable lean weight were quite low. Simple correlation coefficients between total separable carcass lean and the lean of various wholesale cuts were 0.95 with the round, 0.93 with the chuck, 0.81 with the foreshank, 0.80 with the sirloin and 0.75 with the short loin. This work suggests that the lean content of these beef cuts (especially the round) may be valuable in predicting the total carcass muscling in beef.

Orme *et al.* (1960) used 43 mature Hereford cows in a study of methods of predicting total carcass lean. The weights of eight muscles or muscle groups accounted for 62 to 92 percent of the variation in total separable carcass lean. With slaughter weight held constant, the standard partial regression coefficients obtained between the weight of the total carcass lean and the weight of certain muscles or muscle groups were: *b. femoris*, 0.97; sirloin tip muscle group, 0.82; *l. dorsi*, 0.79; and inside round group, 0.72. The regressions of total carcass lean on the weight of the *b. femoris*, *l. dorsi*, the major muscles in the sirloin tip and inside round were 12.36, 10.24, 16.27 and 14.31 lb. of lean, respectively. These results indicate the validity of using the weight of certain entire muscles to estimate the degree of muscling in a particular mature beef carcass.

Martin et al. (1966) studied the association of beef carcass conformation with thick and thin muscle yields. Ten low Choice and 10 high Standard conformation steer carcasses paired on carcass weight, l. dorsi area and fat thickness at the twelfth rib were used. The muscles considered as thick were those of the muscles or muscle systems of the hindquarter which were 5.1 cm. or more in depth and considered to be suitable for steak, plus the muscles of the forequarter which were 7.6 cm. or more in depth and considered to be suitable for roasting. It was shown that Standard conformation carcasses produced longer, wider and thinner muscles and muscle systems than the Choice carcasses. However, advantages in length and width of muscles from the Standard carcasses disappeared when the muscles were trimmed in accordance with minimum thickness requirements for thick muscle. Consistent and significant advantages for Choice conformation carcasses were observed in the yield of thick, high value muscle. However, it was found that, within this selected population, total muscle was relatively constant over a range of carcass shapes.

Knox (1957) examined the interrelationships of type, performance and carcass characteristics. He concluded that beef may be produced more cheaply by rapid growing cattle which reach the desired weight at younger ages, since younger cattle require less feed per unit of gain.

Little et al. (1966) showed that, as the feeding period was lengthened, dressing percent, marbling score, l. dorsi area, fat thickness, kidney fat and carcass weight significantly increased. The estimated percent of retail cuts decreased significantly as feeding period was lengthened.

Guenther _et al_. (1965) used 36 half-sib Hereford steer calves in a study of the growth and development of the major carcass tissues in beef calves from weaning to slaughter weight. Calves were fed on either an intermediate or a high plane of nutrition. The data were compared both on an age constant and a weight constant basis. Lean deposition reached its maximum rate during the early part of the feedlot test and diminished as the animals approached maturity. At 10.8 months of age, calves on high feeding levels had accumulated 86 percent of their ultimate carcass lean while those on the intermediate feeding had accumulated 78 percent. Fat accumulation was most rapid during the latter half of the feeding period and showed a sharp increase after lean production began to subside. When the experimental steers weighed approximately 355 kg. and were almost 11 months old, the lean to fat ratio became less desirable as the feedlot period was extended.

III. ULTRASONIC ESTIMATES

The use of ultrasonic techniques to estimate carcass variables has opened new avenues of approach to meat animal improvement. Stouffer _et al_. (1961) developed an ultrasonic technique for producing cross sectional outlines of the _l. dorsi_ muscle and associated fat layers at the thirteenth rib of live cattle and hogs. Data involving 327 cattle and 42 hogs were reported. A comparison of ultrasonic estimates of _l. dorsi_ area with actual areas gave significant but low associations.

Problems of measurement in this study were positional variation of l. dorsi area and fat thickness between the twelfth and thirteenth ribs, changes in shape and size of the muscle due to slaughtering and hanging, and variability in pressure of the transducer on the hide during ultrasonic measuring.

Hedrick *et al.* (1962) used an ultrasonic device to estimate *l. dorsi* area and fat thickness in four groups of live cattle. The simple correlation coefficients between estimated and actual *l. dorsi* area varied from 0.58 to 0.89. Correlation coefficients between estimated and actual fat thickness varied from 0.11 to 0.63. Scribing of the spinous processes in slaughtering was thought to cause error in relating live fat thickness to carcass fat thickness. It was concluded that the ultrasonic method was acceptable for estimating *l. dorsi* area and fat thickness in live cattle.

Shepard (1964) concluded that ultrasonic estimates of fat thickness and *l. dorsi* area are fair indicators of carcass fat thickness and *l. dorsi* area. Williams (1965) found that ultrasonic estimates of *l. dorsi* and *b. femoris* muscle areas and fat over these muscles could be made with a reasonable degree of accuracy. Watkins *et al.* (1967) calculated highly significant correlation coefficients between the ultrasonically estimated and actual subcutaneous fat thickness (r = 0.90) and between estimated and actual *l. dorsi* muscle area (r = 0.56). Sumption (1964) found a pooled simple correlation coefficient of 0.63 between an ultrasonic estimate of fat thickness and actual carcass subcutaneous fat thickness using 770 animals. Bulls, steers and heifers ranging in weight from 700 to 1,500 pounds were included in the study.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. SOURCE OF DATA

Eighty-four weanling Hereford steers were used in a 2-year study. In the first year (trial 1), 36 male calves were selected at the end of the 1964 grazing season at the University of Tennessee Atomic Energy Commission Beef Cattle Unit at Oak Ridge. The cattle were the progeny of three sires and were as nearly alike in initial age, weight and grade as possible. Feeder grades were Good and Choice. The calves were castrated and placed on a high roughage ration until the experiment was begun on December 15. The steers were randomly allotted, within sire, to 12 lots of 3 steers each. Lots were randomly assigned to three treatments, each treatment being replicated four times.

The second year (trial 2) involved 48 Good and Medium weanling feeder steers purchased at three 1965 East Tennessee feeder calf sales. These calves, purchased in October, were randomly allotted to 12 lots of 4 steers each. Lots were randomly assigned to each of three treatments. Each treatment was replicated four times. The trial was begun after a short adjustment period.

II. FEEDING DATA

Three rations designed to produce three prescribed subcutaneous fat thicknesses were fed (Table I). Ration 1 (treatment 1) was formulated

TABLE I

RATIONS USED TO PRODUCE THREE PRESCRIBED FAT THICKNESSES

Ingredient[a]	Ration (treatment) 1	Ration (treatment) 2	Ration (treatment) 3
Ground shelled corn, lb.	None	4.0	*ad libitum*
Corn silage, lb.	*ad libitum*	*ad libitum*	10.0
Cottonseed meal, lb.	1.5	1.5	1.5

[a] Grass-legume hay was fed at the rate of 4 lb. per head daily in all treatments in the first trial. Hay was used to replace silage for a short time at the end of the trial each year when the corn silage supply was exhausted.

to produce a fat thickness over the *l. dorsi* at the twelfth rib of 3 to 5 mm. after a feeding period of 150 to 175 days. It consisted of an *ad libitum* feeding of corn silage supplemented with 1.5 pounds of cottonseed meal per head daily. Ration 2 (treatment 2) was formulated to produce a fat thickness of 8 to 10 mm. It consisted of an *ad libitum* feeding of corn silage, 4.0 pounds of ground shelled corn and 1.5 pounds of cottonseed meal per head daily. Ration 3 (treatment 3) was designed to produce 13 to 15 mm. of subcutaneous fat. It consisted of an *ad libitum* feeding of ground shelled corn, 10 pounds of corn silage and 1.5 pounds of cottonseed meal per head daily. Four pounds of grass-legume hay was fed per head daily in all treatments in trial 1.

The steers were fed twice daily. The feed not consumed was weighed and subtracted from the total amount fed to obtain total feed consumption.

III. WEIGHING AND GAIN DATA

Individual weights were taken on two consecutive days at the beginning of the trials. The mean of these weights was used as the initial weight. Weights were recorded at approximately 28-day intervals during the trials. Two weights were taken on consecutive days at the end of each trial. The second weight was recorded after the cattle had been without feed and water for approximately 12 hours. The mean of these weights constituted the final weight. Liveweight gains were calculated as the difference between the mean initial and final weights.

IV. ULTRASONIC DATA

Fat deposition was estimated ultrasonically at approximately 28-day intervals in both trials. In trial 1 a Branson Sonoray Model 52 equipped with a tissue scanning device was used primarily. The technique employed followed closely that described by Stouffer *et al.* (1961). Fat thickness was estimated by the interpretation of the time-exposure Polaroid photographs. A Branson Sonoray Model 12 was utilized to estimate the fat thickness in trial 1 on the date immediately prior to slaughter. The location of measurement was between the twelfth and thirteenth ribs and approximately three-fourths the length of the *l. dorsi* from the chine end. The point of measurement was determined by palpation of the posterior edge of the twelfth rib and the lateral edge of the *l. dorsi* muscle. Readings were made directly from the oscilloscope of the Model 12 instrument which was used throughout trial 2. The lead standard furnished with the Branson Model 12 Sonoray was used to calibrate the instrument. This standard was set equal to 3.3 cm. on the oscilloscope.

V. CARCASS DATA

Slaughter Procedure

A compromise in slaughter date was necessary in both trials. In trial 1 the steers in treatment 1 deposited fat at a faster rate than was anticipated. Steers in treatments 2 and 3 attained their desired fat thickness. The steers were slaughtered in four groups at approximately 4-day intervals. The fattest one-fourth of the cattle on each treatment comprised a slaughter group. Slaughtering was done at East Tennessee

Packing Company. In trial 2 the rate of fat deposition was much slower than in the first trial. The cattle in treatments 2 and 3 did not attain the desired fat thickness even though the feeding period was extended beyond the anticipated length. Treatment 1 cattle attained the desired fat thickness. The cattle were slaughtered at Lay Packing Company in four groups at approximately 4-day intervals. The lot in each treatment having the greatest fat thickness comprised a slaughter group. All cattle were trucked approximately 10 miles to the respective packing plants on the morning of slaughter.

Data Obtained at the Packing Plants

Individual hot carcass weights were recorded after dressing and before shrouding. The carcasses were chilled for about 48 hours at approximately 2° C. After chilling, the left side was ribbed between the twelfth and thirteenth ribs. Carcass length, the distance from the anterior edge of the aitch bone to the anterior edge of the first rib adjacent to the first thoracic vertebra, was measured on the right side to the nearest millimeter. The exposed cross section of the *l. dorsi* muscle and the surrounding tissues at the twelfth rib surface were traced on acetate paper. The area of the *l. dorsi* muscle was determined to the nearest 0.01 square inch with a compensating polar planimeter. Subcutaneous fat thickness over the *l. dorsi* between the twelfth and thirteenth ribs was measured to the nearest millimeter at a point three-fourths the length of the *l. dorsi* from the chine end as described by Ramsey *et al.* (1962). Carcass conformation grade, maturity score, marbling score, estimated percent kidney, pelvic and heart fat and carcass grade were obtained from a federal grader.

After being measured and graded, the left side was quartered and shipped to the University of Tennessee Meat Laboratory for further measuring, cutting and palatability studies.

Data Obtained at the Meat Laboratory

All carcasses were aged for 7 days post mortem before processing. Hindquarter measurements were taken prior to cutting (Figure 1). Rump length was measured from the anterior extremity of the ilium (point A) to the posterior extremity of the ischium (point B). External leg length was measured from the distal extremity of the tarsal bones (point E) to a point equidistant between points A and B (point C). Internal leg length was measured from point E to the anterior edge of the aitch bone. Hock to hip length was measured 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 a point which included the posterior one-fourth of the twelfth thoracic vertebra (point F).

The carcasses were broken into wholesale cuts as described by Wellington (1953). The round, loin, rib and chuck were further cut into trimmed, partially boneless retail cuts. Subcutaneous fat in excess of three-eighths inch was trimmed. Intermuscular fat was removed when it was possible to do so without dividing the muscles of the cut. The chine bones were removed from the blade pot roasts and sections of ribs and sternum were removed from the arm pot roasts. The chine bones and rib

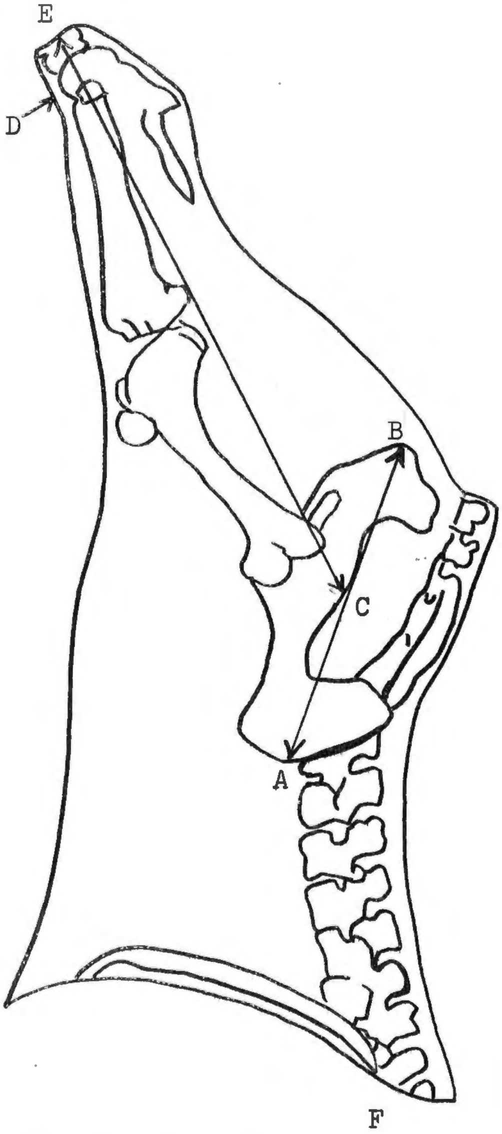

Figure 1. Location of length measurements on the beef hindquarter.

ends were removed from the rib roasts. The sacral vertebrae were removed from the sirloin steaks and all bones were removed from the rump roasts.

The cross sectional area of the _b. femoris_ muscle was measured at a point half-way between the most prominent protuberance of the hock and a point just anterior to the tail-head. This point of measurement was determined on the live steer prior to slaughter. The muscle outline was traced on acetate paper and the area determined to the nearest 0.01 square inch with a compensating polar planimeter. Fat thickness over the _b. femoris_ was measured to the nearest millimeter at this location over the center of the main body of the muscle.

The first-cut club steak was removed from the loin, held at room temperature for 30 minutes and scored for muscle color, muscle texture, muscle firmness and marbling texture. LS Instruction AMS-LSG1 (U.S.D.A., 1963) was used as the basis for the assignment of numerical scores to these factors. Fat color was scored with the use of Munsell Color Paddles.

The 6-7-8 rib roast was retained for cooking, palatability and shear tests. Roasts were wrapped and frozen at -29° C. After freezing they were stored at -18° C. until removal for cooking.

The shankless round was separated into lean, fat and bone since Cole _et al_. (1960b) showed that the lean of this cut was highly related to total carcass lean. The weight of the _b. femoris_ muscle also was recorded. All weights were taken to the nearest 0.1 pound.

VII. COOKING AND PALATABILITY DATA

The cooking of the 6-7-8 rib roasts for cooking, palatability and shear tests was done by the personnel of the Food Science and Institution Management Department of the College of Home Economics. The roasts were cooked in groups of four. Assignment to cooking groups was done at random with no reference to treatment.

The roasts were removed from freezer storage 1 day before testing. They were thawed at room temperature for 8 hours and then were refrigerated overnight in a household refrigerator at approximately 4° C. Prior to cooking, the roasts were wiped with a damp cloth, weighed to the nearest gram and placed fat side up on a rack in a roasting pan. A meat thermometer was placed in each roast with the bulb of the thermometer near the center of the l. dorsi muscle. The roasts were placed in a Despatch oven, which had been preheated to 149° C., and were cooked at this temperature until an internal temperature of 68° C. was reached. After removal from the oven the roasts were cooled at room temperature for 10 minutes before the necessary weights for cooking loss determination were taken. Evaporation loss was determined by subtracting the weight of the pan, rack, drippings and cooked roast from the weight of the pan, rack and uncooked roast. Drip loss was calculated as the difference between the weight of the pan and rack before cooking and the weight of the pan, rack and drippings after cooking. These two components of loss were added to obtain total cooking loss.

Two one-half-inch cores were removed from the l. dorsi muscle of each roast. Each core was sheared four times with a Warner-Bratzler shear device after being cooled to room temperature. The mean of these eight values was used in the statistical analysis.

A six-member experienced sensory panel, consisting of staff from the Animal Husbandry-Veterinary Science, Food Technology and Food Science and Institution Management Departments, scored the roasts for flavor, juiciness and tenderness. A nine-point scale was used for scoring with 9 representing "excellent" and 1 representing "extremely poor." Each panel member received a three-eighths-inch, cross sectional slice from the same anatomical location in each *l. dorsi* muscle. The average of scores by all panel members for each organoleptic trait was used in the statistical analyses.

VIII. METHOD OF ANALYSIS

The data were statistically analyzed using the method of least squares as described by Harvey (1960). Constants were fitted for treatment, year and year-treatment interaction. When these effects were significant, the means were tested with Duncan's (1955) Multiple Range Test. Simple correlation coefficients were calculated on an overall basis among live animal measurements, measures of carcass composition, skeletal measurements, meat characteristics and meat palatability. Simple correlation coefficients between ultrasonic fat estimates and carcass fat thickness were calculated separately for each trial.

CHAPTER IV

RESULTS AND DISCUSSION

I. FEEDLOT PERFORMANCE

Length of Feeding Period

The Good and Choice grade feeder calves from the University's Oak Ridge herd in trial 1 were fed for an average of 150 days. These steers were maintained on a corn silage ration for approximately two months after weaning before being started on the experiment. The Good and Medium steer calves from three East Tennessee feeder calf sales which were used in trial 2 were fed for an average of 185 days. These cattle were started on experiment after a 2-week adjustment period following purchase.

Cost of Gain

An increase in the level of energy in the ration was accompanied by a corresponding increase in the cost of live weight gain (Table II). The cost of live weight gain was higher for all treatments in trial 1 than in trial 2. For ease of interpretation a dressing percent of 56 was assumed for all calves at the initiation of the trials so that carcass weight gain could be calculated. However, the steers in trial 1 had a greater initial fat thickness and may have had a higher initial dressing percent. In trial 1, as the level of energy of the ration increased, the cost of carcass gain increased. The reverse was found in trial 2--an

TABLE II

DAYS ON FEED AND COST OF GAIN[a]

Item	Trial	Treatment 1	2	3
Days on feed	1	150	150	150
	2	185	185	185
Feed cost per 100 lb. of live gain	1	$19.94	$21.83	$23.83
	2	$16.94	$17.02	$18.83
Feed cost per 100 lb. of carcass gain[b]	1	$32.95	$34.15	$35.42
	2	$32.69	$29.70	$28.65

[a] Feed costs used were: corn silage, $8 per ton; corn, $1.40 per bu.; cottonseed meal, $70 per ton; and grass-legume hay, $35 per ton.

[b] Carcass weight gains were calculated by assuming a dressing percent of 56 for the steers when put on feed.

increase in feeding level was accompanied by a decrease in the cost of carcass gain.

Initial and Final Weights

Initial and final weights are presented in Table III. There were no significant differences in initial weight between treatments (Table IV). There was a difference in initial weights between trials ($P < .01$). Steers in trial 1 were heavier than in trial 2. A portion of the difference in weight may be attributed to the period of silage feeding the trial 1 steers received prior to being started on the experiment. Since the exact age of the cattle in trial 2 was unknown, it was not possible to compare the ages of the two groups. The final weights differed significantly ($P < .01$) between treatments. The live weight increased as level of energy in the ration increased. There was a difference between trials in final weights ($P < .05$). The heavier steers initially in trial 1 tended to be heavier at the end of the trial.

Average Daily Gain

Treatment had a significant ($P < .01$) effect upon the rate of gain. The steers which were fed more concentrates produced greater average daily gains (Table V). The cattle in the two trials responded differently to the treatments. Cattle in trial 2 made faster ($P < .01$) daily gains than those in trial 1. The gains made by the cattle in the first trial were lower than expected. This may have been caused by the greater initial fat thickness of the trial 1 cattle.

TABLE III

MEANS FOR FEEDLOT PERFORMANCE

Item	Trial	Treatment 1	Treatment 2	Treatment 3
Initial weight, lb.	1	612.5	610.0	628.2
		487.8	493.9	487.2
Final weight, lb.	1	784.0	818.8	908.2
	2	710.6	807.4	905.0
Average daily gain, lb.	1	1.15	1.40	1.88
	2	1.20	1.70	2.26
Initial fat thickness, mm.[a]	1	4.8	5.3	5.7
	2	1.9	2.0	2.2
Fat thickness increase, mm.[a]	1	4.5	5.4	10.1
	2	3.0	6.4	9.6
Dressing percent	1	57.0	58.0	59.5
	2	54.6	56.5	59.8

[a] Estimated ultrasonically.

TABLE IV

MEAN SQUARES FOR THE EFFECTS OF TREATMENT, YEAR AND YEAR-TREATMENT INTERACTION ON FEEDLOT PERFORMANCE

Source	df	Initial weight	Final weight	Average daily gain	Initial fat thickness[a]	Fat thickness increase[a]	Dressing percent
Treatment	2	417.397	170837.010	5.333*	2.544	255.046**	99.385**
Year	1	327531.750*	17372.340*	1.189**	212.138**	2.425	29.392**
Treatment X year	2	1055.430	9983.28	0.192	0.908	10.455	11.386
Residual	77	1888.190	3661.01	0.060	0.952	5.529	3.134

[a] Estimated ultrasonically.

*$P < .05$.

**$P < .01$.

TABLE V

LEAST SQUARES CONSTANTS AND MEANS FOR THE EFFECTS OF TREATMENT ON FEEDLOT GAIN, FATNESS AND DRESSING PERCENT

Treatment	Initial weight	Final weight	Average daily gain	Initial fat thickness[a]	Fat thickness increase[a]	Dressing percent
	lb.	lb.	lb.	mm.	mm.	
1	-3.13^b	-75.01	-.42	$-.32^b$	-2.75	-1.76
2	-1.32^b	- 9.26	-.04	0.03^b	- .60	- .30
3	4.45^b	84.27	0.46	0.29^b	3.35	2.06
Mean	543.2	819.2	1.61	3.39	6.43	57.46

[a] Ultrasonic estimates.

[b] Constants within a column bearing the same superscript do not differ significantly. All others differ significantly ($P < .05$).

Initial Fat Thickness

The differences between the treatments in ultrasonic estimates of initial fat thickness were not significant (Table V, page 35). There was a significant ($P < .01$) difference in initial fatness between trials. In trial 1 the average initial fat thickness for all treatments was 5.3 mm. while trial 2 steers averaged 2.0 mm. of fat. The difference in initial fatness may have been caused by: (1) pre-weaning environment, (2) differences in genetic capacity to fatten, (3) differences in the time which elapsed between weaning and the beginning of the trial, (4) differences in initial age and weight, and/or (5) a combination of these factors.

Fat Thickness Increase

The increase in fat thickness during the feeding period was significantly ($P < .01$) influenced by treatment (Tables III, IV and V, pages 33, 34 and 35). Treatments with higher levels of ration energy produced a greater deposition of subcutaneous fat. Although initial fat thickness was significantly greater in trial 1 than in trial 2, the difference in fat thickness increase was not significant. Trial 1 cattle, however, required but 150 days to deposit this amount of fat, whereas, those in trial 2 required 185 days.

The rates of fattening are presented in Figure 2. In trial 1 the steers on the lowest level of energy increased gradually from an initial fat thickness of 4.8 mm. on January 12 to 6.5 mm. on April 19. A sharp rise in fat thickness was noted from April 19 to May 7 with an

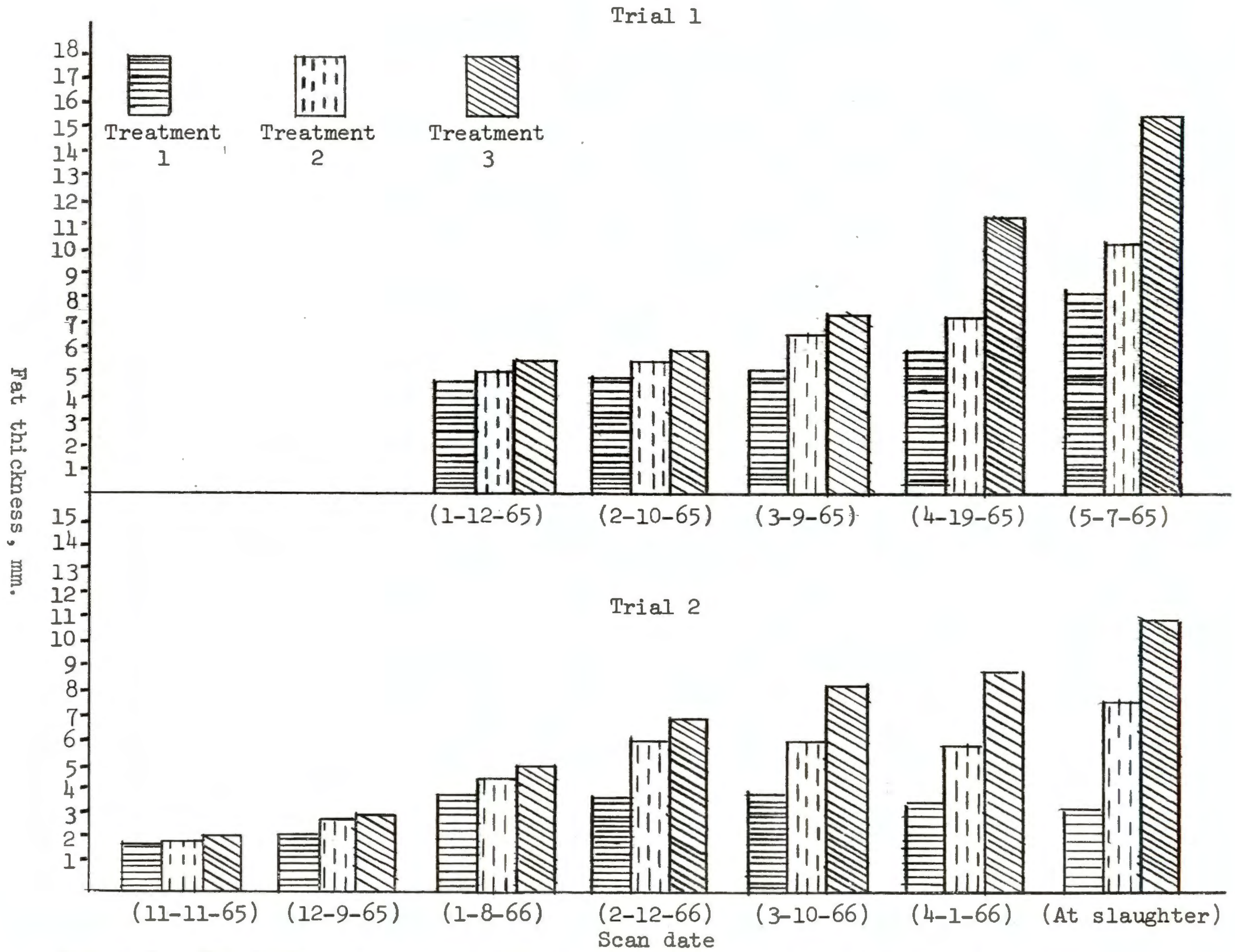

Figure 2. The influence of treatment on ultrasonically estimated fat thickness.

increase from 6.5 mm. to 8.9 mm. The same phenomenon was noted for the intermediate level with an increase from 5.3 mm. on January 12 to 7.6 mm. on April 19. The same rapid increase was noted from April 19 to May 7 with a rise from 7.6 mm. to 10.6 mm. The high level steers performed differently. They showed a gradual increase in fat from an initial estimate of 5.7 mm. on January 12 to 7.5 mm. on March 9. From March 9 to April 19 they deposited fat at a more rapid rate and attained an average thickness of 11.04 mm. During the next period, from April 19 to May 7, the rate of deposition was further accelerated, since an average fat thickness on the latter date of 15.6 mm. was attained.

The steers in trial 2 did not exhibit the same pattern of fattening as those in trial 1. The low level steers, which had 1.9 mm. of fat at the beginning of the trial (November 11), increased in fat thickness gradually to 4.0 mm. on January 8. From January 8 to April 1, they maintained approximately the same fat thickness. The estimate on April 1 was 3.9 mm. From April 1 to just prior to slaughter (the average slaughter date was April 27), the fat thickness increased slightly to 4.9 mm. The intermediate level fattened at a reasonably constant rate from 2.0 mm. of initial fat to 6.0 mm. on February 12. From this date the rate of fattening declined until April 1 when an estimate of 6.3 mm. of fat was recorded. Fat deposition from April 1 to slaughter was rapid. The increase for this period was 2.1 mm. This gave a thickness of 8.2 mm. Treatment 3 steers began the trial with an average of 2.0 mm. of fat and increased in an almost linear fashion to a fat thickness of 11.8 mm. just before slaughter. There was some tendency for the rate of deposition to decline between March 10 and April 1 with a compensating, higher rate of increase for the period just before slaughter.

The results of the first trial tend to agree with those of Guenther *et al.* (1965), who found that fat accumulation was most rapid during the latter half of the feeding period and showed a sharp increase after lean production began to subside. The second trial indicated somewhat the same phenomenon, but fat deposition tended to be more gradual. An accelerated rate of fattening near the end of the feeding period was not clearly demonstrated. The probable reason for the difference in fattening pattern was the difference in the fat level in the latter half of the two trials and/or genetic differences in the two sets of steers.

Dressing Percent

Treatment differences in dressing percent were significant ($P < .01$). Those cattle fed the higher levels of energy had higher dressing percents. The steers on the low and intermediate levels in trial 2 had lower dressing yields than did their corresponding groups in trial 1. There was little difference between years for the steers on the high level of energy (Table III, page 33).

II. CARCASS CHARACTERISTICS

Measures of Muscling, Fatness and Length

Treatment significantly ($P < .01$) affected the area of the *l. dorsi* muscle (Table VI). This measure of muscling did not differ

TABLE VI

MEAN SQUARES FOR THE EFFECTS OF TREATMENT, YEAR AND YEAR-TREATMENT INTERACTION ON MEASURES OF CARCASS MUSCLING, FATNESS AND LENGTH

Source	df	*L. dorsi* area	*B. femoris* area	Fat thickness over *l. dorsi*	Fat thickness over *b. femoris*	Estimated kidney, pelvic and heart fat	Carcass length
Treatment	2	4.932**	15.211**	225.998**	6.026*	7.282*	57.708**
Year	1	8.482**	33.308	216.600**	2.730	43.341**	180.682**
Treatment X year	2	1.019	11.190*	1.910	2.711	0.156	13.726
Residual	77	0.659	2.916	4.543	1.764	0.206	9.592

*P $<$ .05.

**P $<$ .01.

significantly between the low and intermediate treatments but was larger in carcasses of those steers on the high level of energy (Table VII). There was a difference between trials in the area of this major muscle. Least squares constants indicated a difference of 0.64 sq. in. in favor of the trial 2 cattle. Thus the steers in trial 2, although their slaughter weights were lighter, had larger l. dorsi muscles.

The area of the b. femoris muscle has been implicated by Williams (1965) as a good predictor of total carcass muscling. Treatment had a significant ($P < .01$) effect upon the area of this major muscle in the round. Treatments 1 and 2 did not differ, but treatment 3 had a significantly larger average area of b. femoris. The steers in trial 2 had an average of 1.28 sq. in. more area in this muscle cross section than those in trial 1.

Treatment produced a significant ($P < .01$) difference in the fat thickness over the l. dorsi in the carcass (Table VI). The differences among all three levels were significant with fatness increasing as the ration energy level increased (Table VII). A significant ($P < .01$) difference between trials in this measure of carcass fatness also was revealed. Least squares constants showed that the carcasses in trial 1 averaged 3.3 mm. more fat over the l. dorsi than those in trial 2.

The fat thickness over the b. femoris was measured to give an indication of the degree of fattening over the round. Although the round is one of the last areas of the carcass to fatten, this measurement was significantly ($P < .05$) increased by the highest level of feeding. No difference was observed between the low and intermediate levels.

TABLE VII

LEAST SQUARES CONSTANTS AND MEANS FOR THE EFFECTS OF TREATMENT ON MEASURES OF CARCASS MUSCLING, FATNESS AND LENGTH

Treatment	*L.* *dorsi* area	*B.* *femoris* area	Fat over *l. dorsi*	Fat over *b. femoris*	Estimated kidney, pelvic and heart fat	Carcass length
	sq. in.	sq. in.	mm.	mm.	percent	cm.
1	-.34[a]	-.52[a]	-2.72	-.30[a]	-.44	-1.47
2	-.14[a]	-.34[a]	-.34	-.24[a]	-.14	0.00
3	0.48	0.86	3.06	0.54	0.58	1.47
Mean	9.63	15.91	8.02	3.30	1.96	113.16

[a] Constants within a column bearing the same superscript do not differ significantly. All others differ significantly ($P < .05$).

The percent kidney, pelvic and heart fat, estimated by the federal grader, was influenced by treatment. A significant ($P<.05$) increase was noted as feeding level increased. However, the highest level of feeding produced an average of only 2.54 percent of estimated kidney, pelvic and heart fat.

Ration significantly ($P<.01$) affected carcass length (Table VI, page 40). Apparently the faster growing cattle had greater skeletal growth, assuming that carcass length is a criterion of bone development. There was a significant ($P<.01$) difference between trials in carcass length. The carcasses of cattle in trial 1 were 2.98 cm. shorter, although they averaged 29.3 lb. heavier in live weight at the end of the trial.

In general, the linear measurements which were made on the hindquarter were not significantly ($P<.05$) different among treatments (Table VIII). The longest linear measurements were found in the carcasses from treatment 3, although the magnitude of the differences was not significant (Table IX). An exception to this generalization may be found in rump length, which was significantly ($P<.05$) greatest for treatment 3 carcasses. Some significant ($P<.01$) differences were noted between trials. Internal leg length was 1.27 cm. longer and loin length was 0.21 cm. shorter in trial 1 than in trial 2.

Carcass Grading Factors

With the exception of maturity score, which was the same (A-) for all carcasses, treatment significantly ($P<.01$) affected all factors

TABLE VIII

MEAN SQUARES FOR THE EFFECTS OF TREATMENT, YEAR AND YEAR-TREATMENT INTERACTION ON HINDQUARTER MEASUREMENTS

Source	df	Rump length	External leg length	Internal leg length	Hock to hip length	Loin length
Treatment	2	13.742*	7.565	8,373	10.842	8.718
Year	1	0.016	6.155	35.857**	0.442	0.646**
Treatment X year	2	0.644	24.398*	9.324	13.169	2.721
Residual	77	3.473	6.269	4.169	5.103	4.493

*$P < .05$.

**$P < .01$.

TABLE IX

LEAST SQUARES CONSTANTS AND MEANS FOR THE EFFECTS OF TREATMENT ON HINDQUARTER MEASUREMENTS

Treatment	Rump length[a]	External leg length	Internal leg length	Hock to hip length	Loin length
1	0.06[b]	-.21[b]	-.39[b]	-.29[b]	-.36[b]
2	-.75[b]	-.39[b]	-.25[b]	-.44[b]	-.29[b]
3	0.69	0.60[b]	0.64[b]	0.73[b]	0.65[b]
Mean	42.35	77.10	70.60	69.61	58.73

[a] All measurements are in centimeters.

[b] Constants within a column bearing the same superscript letter do not differ significantly. All others differ significantly ($P < .05$).

which determined carcass grade (Table X). Marbling score increased with increases in ration energy (Table XI). Treatment 1 carcasses had an average of slightly more than a traces amount of marbling; treatment 2 carcasses had slight minus; and treatment 3 carcasses had small minus.

Carcass conformation grade increased significantly as feeding level increased. Treatment 1 carcasses had a mean conformation grade of average Good, treatment 2 was mid-way between average and high Good, and treatment 3 carcasses had conformation grades of slightly less than Choice minus. There was a significant ($P < .01$) difference between trials in carcass conformation. Trial 1 carcasses graded higher.

Carcass grade was significantly affected ($P < .01$) by feeding regime. Carcasses from the low level of energy had an average grade of low Good; those from the intermediate level graded slightly less than average Good; and the high level carcasses graded slightly more than high Good. Since maturity scores did not differ, the differences in carcass grade were due to differences in marbling score and/or conformation grade.

III. CARCASS CUTABILITY

Weights of Untrimmed Wholesale Cuts

Treatment effected a significant ($P < .01$) difference in the weight of the left side of the carcasses and the weights of all the untrimmed wholesale cuts from the left side (Tables XII and XIII). The two trials differed significantly ($P < .01$) in side weight. Trial 1 sides averaged 14.54 lb. heavier in weight than those in trial 2.

TABLE X

MEAN SQUARES FOR THE EFFECTS OF TREATMENT, YEAR AND YEAR-TREATMENT INTERACTION ON THE FACTORS DETERMINING CARCASS GRADE[a]

Source	df	Marbling score	Conformation grade	Carcass grade
Treatment	2	13.248**	20.524**	30.670**
Year	1	1.065	13.516**	1.388
Treatment X year	2	0.657	0.198	0.814
Residual	77	0.641	0.696	0.980

[a] Maturity score is omitted because all carcasses received the same score (A-).

*P <.05.

**P <.01.

TABLE XI

LEAST SQUARES CONSTANTS AND MEANS FOR THE EFFECTS OF TREATMENT ON THE FACTORS DETERMINING CARCASS GRADE[a]

Treatment	Marbling score[b,d]	Conformation grade[c,d]	Carcass grade[c,d]
1	-.59	-.79	-.92
2	-.19	-.15	-.26
3	0.78	0.94	1.18
Mean	3.96	10.86	10.04

[a] Maturity is omitted because all carcasses received the same maturity score (A-).

[b] 3 = traces and 4 = slight.

[c] 9 = low Good, 10 = average Good and 11 = high Good.

[d] All treatments differ significantly ($P<.05$).

TABLE XII

MEAN SQUARES FOR THE EFFECTS OF TREATMENT, YEAR AND YEAR-TREATMENT INTERACTION ON LEFT SIDE WEIGHT AND WEIGHT OF UNTRIMMED WHOLESALE CUTS

Source	df	Side	Round	Loin	Rib	Chuck	Flank	Kidney knob	Plate	Brisket	Foreshank
Treatment	2	26742.395**	411.394**	568.742**	296.239**	1413.453**	279.009**	148.400**	403.805**	72.439*	8.188**
Year	1	4303.832**	30.917	42.124	68.360**	63.919	93.544**	86.986**	157.992**	5.871	18.410**
Treatment X year	2	1954.475**	79.359**	73.552**	9.093	223.465**	8.280	2.452	8.068	6.521	0.587
Residual	77	359.731	14.714	10.883	3.891	25.334	3.946	2.564	4.420	2.222	0.631

*P $<$ .05.

**P $<$ .01.

TABLE XIII

LEAST SQUARES CONSTANTS[a] AND MEANS FOR THE EFFECTS OF TREATMENT ON LEFT SIDE WEIGHT AND WEIGHT OF UNTRIMMED WHOLESALE CUTS

Treatment	Side	Round	Loin	Rib	Chuck	Flank	Kidney knob	Plate	Brisket	Foreshank
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1	-29.15	-4.37	-4.13	-3.07	-6.67	-2.91	-2.21	-3.43	-1.57	-.59
2	- 4.55	- .23	- .85	- .48	-1.09	- .58	- .28	- .81	- .14	0.10
3	33.70	4.60	4.98	3.55	7.76	3.49	2.49	4.24	1.71	0.40
Mean	231.56	54.98	36.48	20.01	63.97	13.84	6.75	17.92	9.25	8.32

[a] All treatments differ significantly ($P < .05$).

Trial 1 carcasses had an average yield of 1.82 lb. more untrimmed rib, 2.15 lb. more flank, 2.06 lb. more kidney knob, 2.78 lb. more plate and 0.95 lb. more foreshank than carcasses from trial 2. The differences in all these weights of cuts between trials were significant ($P < .01$).

Yields of Retail Cuts

The weights of partially boneless, closely trimmed retail cuts from the round, rib, loin and chuck were significantly ($P < .01$) affected by treatment (Table XIV). Weights of retail cuts from the round, loin, rib and chuck increased with level of feeding (Table XV). However, it was observed that the retail cuts of the carcasses of the steers from the higher levels of energy feeding contained more fat. Intermuscular fat deposits generally were larger and subcutaneous fat thickness was greater. The latter was true because many carcasses from the lowest level of energy feeding did not have as much as three-eighths-inch of subcutaneous fat--the maximum thickness allowed on the trimmed retail cuts. Thus, at least part of the greater yield of retail cuts from the carcasses of the steers fed the higher energy levels was due to increased fat content.

A significant trial difference was found for cuts from the round, the loin and the rib. Left sides from trial 1 had 5.06 lb. less round cuts but 1.04 lb. more rib cuts and 1.44 lb. more loin cuts. The weight of chuck cuts between trials did not differ.

The percent of the carcass weight in trimmed retail cuts from the round, loin, rib and chuck is one of the major factors in establishing carcass value. Increased energy in the ration significantly decreased

TABLE XIV

MEAN SQUARES FOR THE EFFECTS OF TREATMENT, YEAR AND YEAR-TREATMENT INTERACTION ON YIELD OF PARTIALLY BONELESS, CLOSELY TRIMMED RETAIL CUTS FROM THE ROUND, LOIN, RIB AND CHUCK

Source	df	Round cuts	Loin cuts	Rib cuts	Chuck cuts
Treatment	2	291.129**	151.964**	115.937**	380.091**
Year	1	518.972**	64.597**	22.257**	0.031
Treatment X year	2	61.210**	43.164**	9.228*	112.278**
Residual	77	8.763	7.370	2.420	12.052

*P <.05.

**P <.01.

TABLE XV

LEAST SQUARES CONSTANTS[a] AND MEANS FOR THE EFFECTS OF TREATMENT ON YIELD OF PARTIALLY BONELESS, CLOSELY TRIMMED RETAIL CUTS FROM THE ROUND, LOIN, RIB AND CHUCK

Treatment	Round cuts	Loin cuts	Rib cuts	Chuck cuts
	lb.	lb.	lb.	lb.
1	-3.16	-2.15	-1.95	-3.68
2	- .26	- .41	- .24	- .17
3	3.42	2.56	2.19	3.85
Mean	40.00	29.91	14.44	37.60

[a] All treatments differ significantly ($P < .05$).

the percent of the carcass represented by these major cuts (Tables XVI and XVII). Least squares constants revealed that treatment 1 had 56.32 percent, treatment 2 had 53.33 percent, and treatment 3 had 50.73 percent of trimmed retail cuts from the major wholesale cuts in the carcass. The steers on the two trials differed significantly ($P < .01$) in average cutability. Trial 1 carcasses were 5.16 percent lower in cutting yields than trial 2 carcasses.

In a totally integrated beef production scheme, dressing percentage and cutting yields based on carcass weight may not be given the emphasis which they presently enjoy. The percent of the live weight which is marketable as trimmed retail cuts may be of major importance. Treatment had no significant effect upon the percent of the live weight in the trimmed, partially boneless cuts from the round, loin, rib and chuck. The range in treatment means was only 0.15 percent. Thus, it appears that higher levels of feeding produced higher dressing percents but carcasses of lower cutability. When cutability was expressed on a liveweight basis, these two factors apparently off-set each other. The cattle in trial 1 had 1.48 percent less live weight represented by the trimmed retail cuts from the major wholesale cuts ($P < .01$).

Higher feeding levels significantly ($P < .01$) increased the weight of the trimmed round (Table XVIII). Least squares means for trimmed round weights were 49.74 lb., 53.35 lb., and 57.58 lb. for treatments 1, 2 and 3, respectively (Table XIX). Orme _et al._ (1960) suggested that the weight of the _b. femoris_ was highly related to the weight of the total muscle mass of the carcass. In the present study, the weight

TABLE XVI

MEAN SQUARES FOR THE EFFECTS OF TREATMENT, YEAR AND YEAR-TREATMENT INTERACTION ON TOTAL WEIGHT OF PARTIALLY BONELESS, CLOSELY TRIMMED RETAIL CUTS FROM THE ROUND, LOIN, RIB AND CHUCK AND THE PERCENT OF THE CARCASS WEIGHT AND LIVE WEIGHT REPRESENTED BY THESE CUTS

Source	df	RLRC[a] cuts weight	Percent of carcass of RLRC cuts	Percent of live weight of RLRC cuts
Treatment	2	3560.003**	209.862**	0.150
Year	1	102.581	539.707	45.361**
Treatment X year	2	787.451**	19.965	10.132**
Residual	77	82.596	21.196	1.171

*P $<$.05.

**P $<$.01.

[a] Round, loin, rib and chuck.

TABLE XVII

LEAST SQUARES CONSTANTS[a] AND MEANS FOR THE EFFECTS OF TREATMENT ON THE TOTAL WEIGHT OF PARTIALLY BONELESS, CLOSELY TRIMMED RETAIL CUTS FROM THE ROUND, LOIN, RIB AND CHUCK AND THE PERCENT OF THE CARCASS WEIGHT AND LIVE WEIGHT REPRESENTED BY THESE CUTS

Treatment	RLRC[b] cuts weight	Percent of carcass in RLRC cuts	Percent of live weight in RLRC cuts
	lb.		
1	-10.97	2.86	0.01[a]
2	- 1.08	-.13	0.07[a]
3	12.05	-2.73	-.08[a]
Mean	121.94	53.46	29.78

[a] Constants within a column followed by the same superscript do not differ significantly. All others differ significantly ($P < .05$).

[b] Round, loin, rib and chuck.

TABLE XVIII

MEAN SQUARES FOR THE EFFECTS OF TREATMENT, YEAR AND YEAR-TREATMENT INTERACTION ON TRIMMED ROUND WEIGHT, *B. FEMORIS* WEIGHT AND THE WEIGHT OF THE SEPARABLE COMPONENTS OF THE SHANKLESS ROUND

		Trimmed	*B.*	Separable components of shankless round		
Source	df	round	*femoris*	Muscle	Fat	Bone
Treatment	2	411.394**	5.916**	55.475**	73.768**	0.356
Year	1	30.917	0.001	92.668**	6.956**	1.030
Treatment X year	2	79.359**	1.211	24.985*	3.473*	0.934*
Residual	77	14.714	0.552	5.676	0.909	0.265

*P $<$.05.

**P $<$.01.

TABLE XIX

LEAST SQUARES CONSTANTS AND MEANS FOR THE EFFECTS OF TREATMENT ON TRIMMED ROUND WEIGHT, B. FEMORIS WEIGHT AND THE WEIGHT OF THE SEPARABLE COMPONENTS OF THE SHANKLESS ROUND

Treatment	Trimmed round	B. femoris	Separable components of shankless round		
			Muscle	Fat	Bone
	lb.	lb.	lb.	lb.	lb.
1	-3.82	-.41[a]	-1.42[a]	-1.58	-.13[a]
2	- .20	-.11[a]	- .04[a]	- .16	.10[a]
3	4.02	0.52	1.46	1.74	0.03[a]
Mean	53.56	7.79	30.74	7.79	5.52

[a] Constants within a column followed by the same superscript do not differ significantly. All others differ significantly ($P < .05$).

of this major round muscle was significantly ($P < .01$) greater for the carcasses of steers fed the high level of energy. The *b. femoris* weight did not differ significantly between the low and intermediate levels, but higher feeding levels tended to produce heavier muscle weights.

Cole *et al*. (1960b) reported a simple correlation coefficient of 0.95 between the weight of the separable muscle of the round and total separable muscle in the carcass. Thus, separable muscle of the round is an excellent indicator of separable muscle in the carcass. Treatment 3 produced significantly ($P < .01$) more separable round muscle than the other two treatments (Table XIX, page 58). The observed trend was for an increased feeding level to increase separable round muscle, but the difference in the two lower levels was not significant. A trial difference was noted in this variable. Trial 1 rounds had 2.12 lb. more separable muscle than trial 2 rounds.

Separable fat from the round increased significantly ($P < .01$) with feeding level. Differences among treatments were similar to those of separable muscle. Trial 1 rounds had 0.58 lb. more fat than trial 2 rounds, which was a significant ($P < .01$) difference. Separable bone from the round did not differ significantly ($P < .05$) among treatments.

Year X Treatment Interactions

The analysis of the data revealed several year X treatment interactions between the two trials. The interrelationships of several factors may be responsible for the differences between trials in the response to treatment. All steers were the same breed (Hereford), but they came from different sources. The steers in trial 1 came from the University herds in which selection for improved type and rate of gain had been attempted. The steers used in trial 2 came from East Tennessee feeder calf sales. Although they exemplified typical Hereford characteristics, it is possible that they also possessed other breeding. However, all were sired by purebred Hereford bulls. These steers could be considered more typical of the Hereford feeder steers available in East Tennessee than those used in trial 1.

The feeder grades of the steers on the two trials also differed. Trial 1 feeder steers graded Choice and Good while those in trial 2 graded Medium and Good. Since trial 1 steers averaged 127 lb. more in weight at the beginning of the trial, this may have caused them to respond differently to treatment than the lighter steers in trial 2. The average initial fat thickness in the first trial exceeded that in the second trial by 3.2 mm. This difference in fatness possibly affected the response to treatment in both performance and carcass characteristics. The fat thickness increase of the two trials did not differ although the average daily gain was significantly greater for the second trial. Thus, the composition of the gains made by trial 2 steers had a more favorable lean to fat ratio than those made by the slower-growing steers in trial 1.

Steers in trial 2 gained faster, but because of the heavier initial weights in the first trial, steers in treatments 1 and 2 had 73.4 lb. and 11.4 lb. advantages, respectively, in final weight over the same treatments in trial 2. The average final weight of treatment 3 in both trials differed only slightly.

The variables with significant year X treatment interactions are shown in Table XX. In general, these interactions probably can be explained by differences in fatness, carcass weight and muscle development.

IV. MEAT CHARACTERISTICS

Muscle Color, Texture and Firmness

The color, texture and firmness of beef have been suggested as possible causes for variation in palatability. Brady (1937) stated that texture was an indication of tenderness since finer-textured meat was more tender. Pilkington *et al*. (1960) found a simple correlation coefficient of 0.90 between firmness and fat content. He stated further that, when fat content was held constant, softer rib steaks tended to be more tender than firmer rib steaks. These muscle characteristics are used by consumers in their appraisal of the freshness and potential palatability of retail cuts of beef prior to purchase.

Muscle color was significantly ($P < .01$) affected by treatment (Tables XXI and XXII). The loin steaks from the treatment 3 carcasses were significantly brighter in color than the other two treatments which did not differ significantly. The average muscle color score for carcasses from treatment 3 was 5.41 (between slightly dark red and cherry red). This brighter color was considered more desirable than the darker color of muscle from steers in treatments 1 and 2. Treatment 1 and 2 muscle color scores were 4.68 and 4.61, respectively (slightly dark red minus).

TABLE XX

TREATMENT MEANS FOR VARIABLES WITH A SIGNIFICANT YEAR-TREATMENT INTERACTION

Trial	Treatment	Dressing percent	*B. femoris* area	Side weight	Untrimmed round weight	Untrimmed loin weight	Untrimmed chuck weight	Round cuts weight	Loin cuts weight	Rib cuts weight	Chuck cuts weight	RLRC[a] retail cuts weight	Live weight in RLRC retail cuts	Trimmed round weight	Round separable muscle weight	Round separable fat weight	Round separable bone weight
		percent	sq. in.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	percent	lb.	lb.	lb.	lb.
1	1	56.98	15.09	220.47	53.71	35.07	61.50	35.50	30.12	13.73	35.94	115.30	29.40	52.17	31.54	6.82	5.48
1	2	58.02	15.12	233.88	56.28	35.99	63.42	36.72	30.45	14.73	37.46	119.36	29.18	54.17	31.91	8.14	5.78
1	3	59.53	15.29	266.60	59.35	41.01	70.25	39.07	32.32	16.72	39.38	127.49	28.13	56.56	32.49	9.46	5.47
Mean		58.14	15.16	239.56	56.36	37.25	64.91	37.04	30.92	15.01	37.54	120.52	28.93	54.23	31.96	8.10	5.65
2	1	54.64	15.48	187.26	47.98	29.93	53.49	37.44	25.70	11.44	31.92	106.44	29.92	47.55	27.43	5.72	5.13
2	2	56.53	15.81	223.06	53.69	35.57	62.73	42.01	28.88	13.85	37.42	122.16	30.27	52.80	29.83	7.23	5.48
2	3	59.75	18.06	266.86	60.27	42.24	73.62	47.04	32.96	16.75	43.56	140.31	31.02	58.84	32.25	9.71	5.66
Mean		56.97	16.45	225.72	53.98	35.91	63.28	42.16	29.18	14.01	37.63	122.97	30.40	53.06	29.84	7.55	5.42

[a] Round, loin, rib and chuck.

TABLE XXI

MEAN SQUARES FOR THE EFFECTS OF TREATMENT, YEAR AND YEAR-TREATMENT INTERACTION ON MUSCLE AND FAT CHARACTERISTICS

Source	Muscle color	Muscle testure	Muscle firmness	Fat color	Marbling texture
Treatment	5.153**	2.179*	6.921**	0.440	1.023
Year	2.204*	0.655	0.449	13.246**	0.888
Treatment X year	0.481	0.504	1.026	0.011	0.849
Residual	0.544	0.590	0.521	0.206	0.363

*$P<.05$.

**$P<.01$.

TABLE XXII

LEAST SQUARES CONSTANTS AND MEANS FOR THE EFFECTS OF TREATMENT ON MUSCLE COLOR, TEXTURE AND FIRMNESS, FAT COLOR AND TEXTURE OF MARBLING

Treatment	Muscle color[a]	Muscle texture[b]	Muscle firmness[c]	Fat color[d]	Marbling texture[e]
1	-.22[f]	-.30[f]	-.49	0.11[f]	0.16[f]
2	-.29[f]	0.05[f,g]	-.04	-.14[f]	0.06[f]
3	0.51	0.25[g]	0.53	0.03[f]	-.22[f]
Mean	4.90	4.11	4.26	2.78	2.00

[a] 1 = black, 2 = very dark red, 3 = dark red, 4 = moderately dark red, 5 = slightly dark red, 6 = cherry red and 7 = very light cherry red.

[b] 1 = very coarse, 2 = coarse, 3 = slightly coarse, 4 = slightly fine, 5 = moderately fine, 6 = fine and 7 = very fine.

[c] 1 = extremely soft, 2 = very soft, 3 = soft, 4 = slightly firm, 5 = moderately firm, 6 = firm and 7 = very firm.

[d] Munsell values; higher values indicate a more yellow color.

[e] 1 = coarse, 2 = medium and 3 = fine.

[f,g] Constants within a column followed by the same superscript do not differ significantly. All others differ significantly ($P < .05$).

The magnitude of the differences in muscle texture was not great, although a tendency was shown for the higher levels to have more desirable (finer) texture. Only the difference between treatments 1 and 3 was significant ($P < .05$). The average muscle texture score was 4.11 (slightly fine). The treatment means were 3.81, 4.16 and 4.36 for the texture of muscle from steers in treatments 1, 2 and 3, respectively.

An increase in level of energy in the ration was found to significantly ($P < .01$) increase the muscle firmness (Table XXII). The average firmness rating for all treatments was 4.26 (slightly soft plus). Average scores of 3.77 (slightly soft minus), 4.22 (slightly soft plus) and 4.79 (moderately firm minus) were found for treatments 1, 2 and 3, respectively.

Fat Color

Fat color, which was assessed with Munsell Color Paddles, did not differ among treatments (Table XXI, page 63). No trends in fat color which could be ascribed to treatment were noted (Table XXII, page 64). However, there was a significant ($P < .01$) difference between years. Trial 1 carcasses had significantly lower (whiter) scores than trial 2 carcasses. This difference may have been effected by the greater thickness of subcutaneous fat in trial 1.

Marbling Texture

The texture of marbling is assumed to have some effect upon palatability. Fine, evenly dispersed marbling is considered the most desirable. Treatment had no significant effect on marbling texture although a trend was noted (Table XXII, page 65) for marbling to become coarser as energy level of the ration increased.

Cooking Losses

Evaporation loss of the 6-7-8 rib roasts in all trials averaged 17.71 percent. No significant differences were noted between treatments for this component of cooking loss (Tables XXIII and XXIV), but there was a significant ($P < .01$) difference between trials. Roasts in trial 1 lost 2.41 percent more due to evaporation than those in trial 2. The probable reason for the greater evaporation loss of the trial 1 roasts was that their average weight was 203 grams more, and they required an average of 27.7 minutes more cooking time than the roasts in trial 2.

Drip loss increased significantly as feeding level increased. Drip losses were 3.09, 3.65 and 4.24 percent for treatments 1, 2 and 3, respectively. There also was a difference between trials in drip loss. Trial 1 losses exceeded trial 2 by 0.84 percent in this component of cooking loss. The probable explanation of this difference was the greater amount of intermuscular fat in the trial 1 roasts from the higher feeding levels since subcutaneous fat was trimmed to a uniform thickness when the trimmed retail cuts were fabricated.

Organoleptic Properties

A six-member, experienced sensory panel scored samples of the *l. dorsi* from the 6-7-8 rib roast for flavor, juiciness and tenderness. Flavor scores were not significantly affected by treatment (Table XXV). No trends were observed which could be attributed to treatment (Table XXVI).

TABLE XXIII

MEAN SQUARES FOR THE EFFECTS OF TREATMENT, YEAR AND YEAR-TREATMENT INTERACTION ON PERCENT COOKING LOSSES OF 6-7-8 RIB ROASTS

Source	df	Evaporation loss	Drip loss
Treatment	2	4.194	9.083**
Year	1	117.506**	14.839**
Treatment X year	2	0.199	2.592*
Residual	77	3.694	0.509

*P < .05.

**P < .01.

TABLE XXIV

LEAST SQUARES CONSTANTS AND MEANS FOR THE EFFECTS OF TREATMENT ON PERCENT COOKING LOSSES OF 6-7-8 RIB ROASTS

Treatment	Evaporation loss	Drip loss
	percent	percent
1	-.42^a	-.59
2	0.35^a	0.03
3	0.07^a	0.56
Mean	17.71	3.68

[a] Constants within a column followed by the same superscript do not differ significantly. All others differ significantly ($P < .05$).

TABLE XXV

MEAN SQUARES FOR THE EFFECTS OF TREATMENT, YEAR AND YEAR-TREATMENT INTERACTION ON SENSORY PANEL SCORES AND WARNER-BRATZLER SHEAR VALUES

Source	Sensory panel score			Warner-Bratzler shear value
	Flavor	Juiciness	Tenderness	
Treatment	0.099	0.182	3.788**	13.727**
Year	2.130**	5.563**	11.607**	47.218**
Treatment X year	0.187	0.175	0.179	0.523
Residual	0.094	0.173	0.413	1.882

*P <.05.

**P <.01.

TABLE XXVI

LEAST SQUARES CONSTANTS AND MEANS FOR THE EFFECTS OF TREATMENT ON SENSORY PANEL SCORES AND WARNER-BRATZLER SHEAR VALUES

	Sensory panel score			
Treatment	Flavor[a]	Juiciness[a]	Tenderness[a]	Warner-Bratzler shear value
1	$-.06^b$	0.09^b	0.33^b	$-.64^b$
2	0.05^b	$-.02^b$	0.08^b	$-.14^b$
3	0.01^b	$-.07^b$	-.41	0.78
Mean	7.66	7.20	7.45	6.90

[a] Based on a 9-point hedonic scale; 1 = extremely poor, 9 = excellent.

[b] Constants within a column followed by the same superscript do not differ significantly. All others differ significantly ($P < .05$).

However, there was a significant difference ($P < .01$) between trials. Trial 1 roasts were scored an average of 0.32 point lower in flavor than those from trial 2.

Juiciness scores were not significantly affected by treatment. There was a slight tendency for juiciness scores to decrease as energy level of the ration increased. A significant ($P < .01$) trial difference was found in this attribute of eating quality. Trial 1 roasts averaged 0.52 point lower in juiciness that trial 2 roasts.

Tenderness is considered the most important component of beef palatability. Tenderness tended to decrease as feeding level increased. The roasts from treatment 3 were scored significantly ($P < .01$) less tender than those from treatments 1 and 2 (Table XXVI, page 70). This finding is contrary to the reports by Barbella _et_ _al_. (1939), Wanderstock and Miller (1948), Pilkington _et_ _al_. (1960) and Walter _et_ _al_. (1965). These and other workers have found either no relationship of fatness to tenderness or a small positive relationship. There was a difference ($P < .01$) between trials in panel scores for tenderness. Trial 1 roasts were 0.74 point less tender than those from trial 2. This difference may have been due to the change in one panel member in trial 2 or to genetic or environmental factors.

Warner-Bratzler Shear Value

The Warner-Bratzler shear is widely accepted as an objective measure of meat tenderness. Shear values tended to corroborate the findings of the sensory panel. Shear values did not differ significantly between treatments 1 and 2, but treatment 3 had significantly ($P < .01$)

higher (less tender) values (Table XXVI, page 70). Shear value tended to increase with increased feeding level. A trial difference was noted for shear value. The mean value of trial 1 roasts was 1.53 lb. greater than the mean value for trial 2. The reason for the difference between trials in both subjective and objective tenderness evaluation is not apparent. Genetic and/or environmental causes may be involved.

V. CORRELATIONS BETWEEN TRAITS

General Characteristics

The simple correlation coefficients calculated on an overall basis are presented in Tables XXVII and XXVIII.

Carcass fat thickness measured over the l. dorsi muscle was significantly ($P < .01$) related to final live weight ($r = 0.66$), dressing percent ($r = 0.71$), side weight ($r = 0.76$) and average daily gain ($r = 0.48$). The correlations between final live weight and the weights of the left side and major wholesale cuts of the carcass were very high (side weight, $r = 0.96$; untrimmed round weight, $r = 0.93$; rib weight, $r = 0.93$; chuck weight, $r = 0.93$; and loin weight, $r = 0.91$). Thus final live weight accounted for 83 to 92 percent of the variation in these measures of carcass yield. Side weight was associated with 25 percent of the variation in carcass length. Side weight also was related to l. dorsi area ($r = 0.45$) and b. femoris area ($r = 0.49$). Increases in weight, therefore, tended to be accompanied by increases in muscle area.

TABLE XXVII

SIMPLE CORRELATION COEFFICIENTS BETWEEN CARCASS AND PRODUCTION TRAITS[a,b]

Variable	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. *L. dorsi* area	0.39	0.40	0.22	0.45	0.43	-.09	0.04	0.57	0.29	0.19	0.29	0.55	0.31	0.43	0.48	0.66	0.43	0.48	0.46	0.42	0.45	0.60	0.23	0.38	0.36	0.57	0.51	0.47	0.56	0.23	0.39	-.04	0.47	0.07
2. Carcass fat thickness	-.20	0.71	0.77	0.48	0.66	0.47	-.52	0.54	0.80	0.72	0.62	0.56	0.80	0.62	0.72	0.27	0.49	0.64	0.69	0.77	0.76	0.01	0.24	0.76	0.56	0.41	0.60	0.66	0.15	0.32	0.62	0.76	0.10	
3. Carcass length	0.24	0.22	0.30	0.57	0.57	-.07	0.02	0.65	0.38	0.28	0.24	0.51	0.34	0.49	0.52	0.66	0.60	0.58	0.47	0.45	0.50	0.68	0.28	0.40	0.27	0.54	0.51	0.47	0.50	0.40	0.31	-.08		
4. Kidney, pelvic and heart fat percent	-.42	0.59	0.45	0.17	0.54	0.76	-.57	0.33	0.70	0.74	0.64	0.34	0.71	0.55	0.55	-.06	0.31	0.48	0.57	0.64	0.62	-.32	0.32	0.58	0.57	0.35	0.48	0.57	0.01	0.12	0.44			
5. Carcass grade	0.54	0.59	0.61	0.56	0.63	0.20	-.36	0.63	0.69	0.58	0.48	0.61	0.72	0.58	0.67	0.44	0.59	0.66	0.69	0.74	0.70	0.20	0.08	0.69	0.38	0.42	0.54	0.56	0.31	0.38				
6. Fat over *b. femoris*	0.03	0.33	0.37	0.35	0.37	0.01	-.09	0.37	0.35	0.24	0.16	0.32	0.37	0.25	0.40	0.35	0.34	0.40	0.39	0.40	0.39	0.27	0.05	0.43	0.12	0.22	0.30	0.32	0.24					
7. *B. femoris* area	0.41	0.40	0.28	0.54	0.49	-.11	0.24	0.65	0.34	0.23	0.30	0.47	0.35	0.51	0.53	0.70	0.56	0.52	0.44	0.39	0.49	0.65	0.27	0.37	0.51	0.71	0.61	0.55						
8. Untrimmed round weight	0.04	0.68	0.59	0.71	0.93	0.43	-.41	0.91	0.83	0.70	0.79	0.75	0.86	0.88	0.89	0.70	0.80	0.90	0.87	0.87	0.94	0.48	0.66	0.85	0.89	0.87	0.99							
9. Trimmed round weight	0.12	0.66	0.56	0.74	0.91	0.34	-.34	0.92	0.80	0.64	0.76	0.76	0.80	0.87	0.87	0.77	0.81	0.89	0.84	0.83	0.92	0.56	0.67	0.82	0.89	0.90								
10. *B. femoris* weight	0.17	0.53	0.41	0.65	0.80	0.26	-.17	0.83	0.68	0.52	0.66	0.67	0.65	0.77	0.76	0.74	0.71	0.78	0.72	0.69	0.79	0.56	0.58	0.65	0.83									
11. Round separable muscle weight	0.02	0.54	0.39	0.47	0.76	0.54	-.31	0.74	0.68	0.56	0.73	0.57	0.68	0.78	0.71	0.53	0.66	0.74	0.73	0.69	0.77	0.27	0.66	0.62										
12. Round separable fat weight	0.04	0.75	0.71	0.76	0.85	0.28	-.48	0.84	0.88	0.73	0.66	0.76	0.89	0.80	0.88	0.63	0.76	0.86	0.83	0.87	0.92	0.36	0.37											
13. Round separable bone weight	0.00	0.26	0.17	0.30	0.54	0.40	-.22	0.51	0.41	0.30	0.61	0.36	0.38	0.56	0.47	0.37	0.47	0.50	0.43	0.39	0.50	0.34												
14. Hind shank weight	0.49	0.24	0.33	0.66	0.46	-.41	0.12	0.64	0.24	0.09	0.17	0.57	0.24	0.35	0.46	0.86	0.52	0.46	0.38	0.32	0.41													
15. Side weight	-.03	0.74	0.72	0.78	0.96	0.40	-.46	0.91	0.94	0.82	0.75	0.80	0.94	0.88	0.95	0.66	0.83	0.95	0.92	0.96														
16. Rib weight	-.13	0.70	0.72	0.74	0.93	0.43	-.52	0.83	0.90	0.83	0.71	0.74	0.94	0.80	0.90	0.56	0.75	0.88	0.96															
17. Rib cuts weight	-.04	0.67	0.66	0.72	0.91	0.41	-.48	0.85	0.84	0.75	0.72	0.73	0.90	0.78	0.88	0.59	0.77	0.85																
18. Chuck weight	0.08	0.66	0.63	0.79	0.93	0.30	-.33	0.93	0.85	0.71	0.65	0.75	0.86	0.84	0.90	0.71	0.90																	
19. Chuck cuts weight	0.30	0.56	0.51	0.78	0.84	0.15	-.21	0.93	0.71	0.57	0.51	0.64	0.73	0.77	0.82	0.71																		
20. Round cuts weight	0.48	0.43	0.47	0.82	0.68	-.25	0.00	0.86	0.52	0.33	0.34	0.74	0.50	0.60	0.67																			
21. Loin weight	0.07	0.75	0.70	0.76	0.91	0.33	-.40	0.91	0.86	0.74	0.69	0.77	0.87	0.90																				
22. Loin cuts weight	0.13	0.64	0.49	0.61	0.86	0.46	-.34	0.87	0.80	0.66	0.74	0.69	0.77																					
23. Plate weight	-.18	0.71	0.72	0.70	0.90	0.47	-.55	0.78	0.92	0.84	0.72	0.68																						
24. Brisket weight	0.18	0.63	0.64	0.71	0.75	0.11	-.26	0.79	0.74	0.59	0.60																							
25. Foreshank weight	-.19	0.56	0.46	0.40	0.73	0.63	-.45	0.61	0.71	0.59																								
26. Kidney and pelvic fat weight	-.35	0.57	0.67	0.62	0.80	0.45	-.53	0.62	0.83																									
27. Flank weight	-.17	0.70	0.74	0.71	0.89	0.43	-.54	0.78																										
28. RLRC, cuts weight	0.30	0.63	0.58	0.84	0.91	0.16	-.25																											
29. Percent of carcass in RLRC cuts	0.35	-.40	-.45	-.20	-.40	-.45																												
30. Initial live weight	-.52	0.26	0.10	-.19	0.40																													
31. Final live weight	-.12	0.55	0.67	0.81																														
32. Average daily gain	0.14	0.46	0.69																															
33. Ultrasonic fat increase	-.14	0.57																																
34. Dressing percent	0.25																																	
35. Percent of live weight in RLRC cuts																																		

[a] Calculated on an overall basis.

[b] All correlation coefficients are based on 82 degrees of freedom. Values of 0.22 and 0.28 are required for significance at the 0.05 and 0.01 levels of probability, respectively.

TABLE XXVIII

SIMPLE CORRELATION COEFFICIENTS BETWEEN CARCASS, PALATABILITY AND PRODUCTION TRAITS[a,b]

Variable	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2
1. *L. dorsi* area	0.22	0.45	-.12	0.11	-.19	0.04	-.12	0.18	0.24	0.08	0.24	0.22	0.11	0.22	0.23	0.39	-.04	0.31	0.36	0.07
2. Carcass fat thickness	0.77	0.48	0.44	0.64	0.26	0.44	-.41	-.20	-.08	-.34	-.31	0.32	0.08	0.35	0.32	0.62	0.76	0.62	0.60	
3. Marbling score	0.56	0.50	0.24	0.40	0.11	0.31	-.35	-.09	0.02	-.14	-.03	0.35	0.04	0.40	0.33	0.93	0.43	0.49		
4. Conformation grade	0.56	0.49	0.40	0.56	0.24	0.30	-.49	-.18	-.05	-.34	-.17	0.41	0.18	0.32	0.25	0.61	0.64			
5. Kidney, pelvic and heart fat percent	0.45	0.17	0.57	0.62	0.42	0.48	-.56	-.41	-.29	-.33	-.44	0.15	-.02	0.37	0.12	0.44				
6. Carcass grade	0.61	0.56	0.25	0.44	0.12	0.33	-.40	-.12	0.05	-.15	-.02	0.48	0.16	0.45	0.38					
7. Fat over *b. femoris*	0.37	0.35	0.03	0.28	-.09	0.05	-.06	0.00	0.00	-.20	0.06	0.34	0.09	0.13						
8. Muscle color	0.24	0.37	0.17	0.30	0.07	0.32	-.27	-.21	-.09	-.10	-.12	0.30	0.32							
9. Muscle texture	0.12	0.24	-.02	0.20	-.10	-.02	-.07	-.11	0.06	0.05	-.05	0.61								
10. Muscle firmness	0.41	0.40	0.00	0.26	-.11	0.20	-.25	-.07	0.03	-.02	0.00									
11. Fat color	-.03	0.16	-.37	-.26	-.33	-.31	0.31	0.36	0.25	0.06										
12. Marbling texture	-.23	-.12	-.12	-.27	-.03	0.07	0.05	-.16	0.01											
13. Flavor	0.15	0.22	-.28	-.18	-.26	-.29	0.31	0.49												
14. Juiciness	-.04	-.05	-.57	-.29	-.56	-.47	0.49													
15. Tenderness	-.40	-.30	-.61	-.56	-.50	-.77														
16. W - B shear value	0.37	0.22	0.46	0.38	0.39															
17. Evaporation loss	0.07	-.04	0.94	0.32																
18. Drip loss	0.53	0.40	0.62																	
19. Total cooking loss	0.25	0.11																		
20. Average daily gain	0.69																			
21. Ultrasonic fat increase																				

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[a] Calculated on an overall basis.

[b] All correlation coefficients are based on 82 degrees of freedom. Values of 0.22 and 0.28 are required for significance at the 0.05 and 0.01 levels of probability, respectively.

The fat thickness of the carcass measured over the l. dorsi at the 12th rib surface significantly depressed the percentage of the carcass represented in the trimmed, partially boneless retail cuts from the round, loin, rib and chuck ($r = -.52$). However, this relationship was not significant when the weight of these cuts was expressed as a percentage of the live weight ($r = -.20$). Fat thickness was highly related to dressing percentage ($r = 0.71$). This agrees with Mumford (1902), who stated that increasing the yield of carcass is one of the primary reasons for fattening a beef animal.

The relationships between carcass fat thickness and estimated percent kidney, pelvic and heart fat ($r = 0.76$), percent separable fat in the round ($r = 0.76$) and the fat thickness over the b. femoris ($r = 0.32$) were all significant ($P < .01$). The correlation between the estimated percent kidney, pelvic and heart fat and the actual weight of the kidney and pelvic fat was highly significant ($r = 0.74$). Thus, the federal grader was able to account for approximately 50 percent of the actual variation in the kidney and pelvic fat weight by his estimates which were made to the nearest 0.5 percent.

The carcasses with the thicker fat cover had more weight in the thinner, minor wholesale cuts. Fat thickness was associated with 64 percent of the variation in plate weight, 64 percent of the variation in flank weight and 31 percent of the variation in brisket weight.

Muscle Area Measurements

The l. dorsi muscle area is used, primarily because of its ease of measurement in routine packing house procedures, as one of four variables in a regression equation for predicting carcass cutability (Murphey _et al._, 1960). A correlation coefficient of 0.57 was found between this measure of muscling and the actual weight of the partially boneless, trimmed retail cuts from the round, loin, rib and chuck. Because of the high relationship between side weight and the weight of the trimmed major cuts (r = 0.91), the area of _l. dorsi_ accounted for only 18 percent of the variation in trimmed cuts weight when side weight was held constant. The correlation of _l. dorsi_ area and the percent of the carcass weight in trimmed major cuts was not significant (r = 0.04).

Shankless Round Components

Separable muscle of the round has been shown to be highly related to separable muscle in the carcass (Cole _et al._, 1960b). The separable muscle of the round in this study was highly related to the weight of the partially boneless, trimmed, retail cuts from the round, loin, rib and chuck (r = 0.74). Separable round muscle was positively associated with round cuts weight (r = 0.53), loin cuts weight (r = 0.78), rib cuts weight (r = 0.73) and chuck cuts weight (r = 0.66). Round separable muscle weight and side weight also were highly related (r = 0.77).

The simple correlation coefficient of separable muscle of the round and average daily gain was 0.47, while separable fat of the round and average daily gain showed a higher association (r = 0.76). Thus, average daily gain accounted for 22 percent of the variation in separable muscle; while 58 percent of the variation in round separable fat could be attributed to differences in average daily gain.

Separable fat in the shankless round was negatively related to the percent of the carcass in partially boneless, trimmed retail cuts from the round, loin, rib and chuck (r = -.48) but was positively related to the weight of these cuts (r = 0.84). The fat over the *b. femoris* muscle accounted for only 18 percent of the variation in the separable fat weight from the round. If this measure of fat is assumed to be a reliable estimate of subcutaneous fat on the round, intermuscular fat apparently has the dominant role in determining round composition.

Weight of Round

Brungardt and Bray (1963) found that the percent of the carcass in trimmed round made the largest contribution in a multiple regression equation for predicting percent retail yield. The weight of the trimmed round in this study was highly related to the weight of the trimmed retail cuts from the round, loin, rib and chuck (r = 0.92). This finding would, therefore, lend support to the work of Brungardt and Bray. The relationship between trimmed and untrimmed round was very high (r = 0.99). The possibility of using untrimmed round weight in an equation to predict retail yield appears feasible. The correlation coefficient of untrimmed round weight with the weight of trimmed retail cuts was 0.91.

Carcass Conformation Grade

Research concerning the value of carcass conformation in predicting carcass yields has been extensively reviewed (Tyler *et al.*, 1964; Goll *et al.*, 1961b; Henderson *et al.*, 1966; and Martin *et al.*, 1966). The correlation coefficient generated in this study between carcass conformation grade and the percent of the carcass in trimmed, partially boneless retail cuts was -.39. A significant ($P<.01$) negative effect of conformation grade on carcass cutability was shown in these carcasses which varied widely in fatness. The relationship between carcass conformation and fat thickness over the *l. dorsi* was highly significant ($r = 0.62$). Thus, the subjective conformation grade given the carcasses by the federal grader apparently was greatly influenced by fatness.

The relationship between conformation grade and the area of the *l. dorsi* muscle was significant ($P<.01$). However, with fat thickness held constant, *l. dorsi* area accounted for only 12 percent of the variation in conformation grade. The relationship between the increase in fat thickness, measured ultrasonically, and final carcass conformation grade was highly significant ($r = 0.56$).

Fat thickness over the *b. femoris* muscle and conformation score were significantly related, but this measure of fatness accounted for only 6 percent of the variation in conformation grade. The low amount of variation in fat thickness over the *b. femoris* may have been partially the cause of this low relationship.

Marbling Score

Marbling score and fat thickness over the *l. dorsi* were positively related ($r = 0.60$). Thus the variation in subcutaneous fat was associated with 36 percent of the variation in the intramuscular fat deposition, which was subjectively estimated by the federal grader. The correlation coefficients of marbling score with average daily gain and ultrasonic fat thickness increase were 0.50 and 0.56, respectively. The area of _l. dorsi_ muscle and marbling score also showed a significant relationship (r = 0.36). The estimated percent of kidney, pelvic and heart fat was significantly ($P<.01$) related to marbling score (r = 0.43). This measure of fatness was lower in its association with intramuscular fat deposition than was subcutaneous fat thickness. These results show that the fatter carcasses tended to have higher marbling scores.

Carcass Grade

Carcass grade is widely accepted in the beef industry as a means of sorting a heterogeneous population of beef carcasses into homogeneous groups with similar organoleptic properties. Carcass grade was closely associated with marbling score (r = 0.93) in the carcasses of the 83 Hereford steers in this study. Thus, marbling accounted for 86 percent of the variation in carcass grade in these carcasses having the same maturity score (A-). Conformation grade and carcass grade also were significantly related (r = 0.61) as were fat thickness and carcass grade (r = 0.62). Higher grading carcasses tended to have larger _l. dorsi_ areas (r = 0.39), a higher percent of estimated kidney and pelvic fat (r = 0.44) and came from steers with a higher rate of gain (r = 0.56) and a greater increase in subcutaneous fat thickness while on experiment (r = 0.61).

Muscle Color

The color of muscle is important as it affects the saleability of beef. Consumers generally associate darker-colored muscle with advanced animal age and tend to avoid darker-colored beef because of the tendency of older animals to produce less tender cuts.

Subcutaneous fat thickness positively affected muscle color in the current study ($r = 0.35$) with fatter carcasses tending to have brighter muscle. Although this relationship is significant ($P < .01$), fat thickness accounted for but 12 percent of the variation in muscle color. The degree of marbling also was associated with muscle color ($r = 0.40$). Higher grading carcasses had higher muscle color scores ($r = 0.45$). Brighter red muscles tended to have a finer texture ($r = 0.32$), to be firmer ($r = 0.30$) and to come from faster gaining steers ($r = 0.37$).

Color of muscle had little influence upon flavor scores of the muscle in the 6-7-8 rib roasts ($r = -.09$). The relationship between color and juiciness approached significance ($r = -.21$), indicating a tendency for the roasts from carcasses with darker _l. dorsi_ muscles to have higher sensory panel juiciness scores. The relationship with tenderness was highly significant ($r = -.27$), indicating that darker muscle was associated with greater tenderness. The correlation coefficient of Warner-Bratzler shear value and muscle color ($r = 0.32$) substantiates this conclusion.

Muscle Texture

Texture of muscle is thought to be related to meat palatability. Finer-textured muscle is assumed to be more tender. In the current study, subjective scores for texture had little influence on panel tenderness scores (r = -.07) or shear values (r = -.20). The explanation for this low relationship may partially lie in the narrow range of texture scores which were involved. Carcass fat thickness also had a low association with muscle texture (r = 0.08). Carcass grade (r = 0.16), marbling score (r = 0.04), _l. dorsi_ area (r = 0.11) or ultrasonic fat increase (r = 0.12) also were not significantly related to muscle texture. Texture had little or no influence on flavor and juiciness scores. Faster gaining cattle had significantly ($P < .05$) higher texture scores.

Muscle Firmness

Firmer beef muscle is desired since it tends to retain an acceptable shape and appearance for longer periods when subjected to the rigors of retail, fresh meat merchandising. In the present study, firmer beef muscle was associated with thicker subcutaneous fat (r = 0.32), higher marbling scores (r = 0.35) and higher carcass grades (r = 0.48). There was a tendency for larger _l. dorsi_ muscles to be firmer (r = 0.22). Firmer muscles were significantly ($P < .01$) brighter in color (r = 0.30) and finer in texture (r = 0.61). However, firmer muscles were found to be significantly ($P < .05$) less tender by the sensory panel. There was no significant relationship between firmness and sensory panel flavor and juiciness scores. Faster gaining cattle had significantly ($P < .01$) firmer muscle (r = 0.40).

Marbling Texture

The most desired texture of marbling is that which is fine and evenly dispersed throughout the muscle. It is assumed that marbling of this type is more likely to produce desirable palatability than coarser marbling which lacks uniformity of distribution. The relationships found between marbling texture and the palatability traits studied were not significant (flavor, $r = 0.01$; juiciness, $r = -.16$; tenderness, $r = 0.05$; and shear value, $r = -.07$). There was a significant ($P < .01$) negative relationship between carcass fat thickness and marbling texture ($r = -.34$) and a tendency for more highly marbled carcasses to be given lower marbling texture scores ($r = -.14$). A significant ($P < .05$) but low negative relationship was found between ultrasonic fat increase and marbling texture score ($r = 0.23$).

Flavor

Sensory panel flavor scores had a low relationship with carcass grade ($r = 0.05$). Marbling, which greatly influenced beef carcass grades, had little influence on flavor scores ($r = 0.02$). Carcass fat thickness and carcass conformation grade likewise had little effect on flavor ($r = -.08$ and $-.05$, respectively). Average daily gain and _l. dorsi_ area both were significantly ($P < .05$) related to flavor having coefficients of correlation of 0.22 and 0.24, respectively. These results are not in agreement with those of Barbella _et al_. (1939), who found a small but significant association between degree of fatness and desirability of lean flavor. Sliger (1966) showed a significant positive relationship between marbling and panel flavor scores when carcasses of widely varying maturity were compared.

Juiciness

Carcass fat thickness was not significantly related to juiciness scores. A tendency for the roasts from the fatter carcasses to have lower juiciness scores was observed since a simple correlation coefficient of -.20 was found. Carcass grade and marbling score had little effect on panel juiciness scores. These results do not agree with the findings of other workers, who have found positive relationships between meat juiciness scores and the subjective appraisal of the potential eating quality of the carcass (Doty and Pierce, 1961; Wellington and Stouffer, 1959; Walter *et al.*, 1965; and Romans *et al.*, 1965).

There was an interrelationship between juiciness and flavor scores. Variations in juiciness score accounted for 24 percent of the variation in flavor scores. An identical relationship was found between juiciness scores and tenderness scores. Color, texture and firmness of muscle all showed low and non-significant relationships with juiciness. This was true also for marbling texture.

Tenderness

The component of eating quality most desired by beef consumers is tenderness (Brady, 1957). Fat thickness in the current study had a significant ($P < .01$) negative relationship to the tenderness scores given by the sensory panel ($r = -.41$). This same negative relationship with tenderness was shown by marbling score ($r = -.35$) and carcass grade (r = -.40). These findings are not in agreement with other workers who have shown a low, but positive, relationship of tenderness with marbling score, fatness and carcass grade (Wanderstock and Miller, 1948; Doty and Pierce, 1961; Wellington and Stouffer, 1959; and Rogers _et al._, 1966). The steers on the low levels of energy in this study may have been more tender because of the effect of the plane of nutrition on their physiological maturity.

Pilkington _et al._ (1960) suggested that firmness of muscle was related to tenderness. These workers found softer rib steaks to be more tender when fat content was held constant. The simple correlation coefficient generated in this study between muscle firmness and tenderness was -.25 which was significant ($P < .05$). Thus, softer muscle tended to receive higher tenderness scores.

One attribute of palatability (flavor, juiciness or tenderness) may influence the subjective scores given by sensory panel members to another attribute. For example, a desirable tenderness score may contribute to a higher juiciness score. The correlation between tenderness and juiciness of 0.49, between tenderness and flavor of 0.31, and between juiciness and flavor of 0.49 would tend to support this reasoning.

Warner-Bratzler Shear Value

A correlation coefficient of -.77 was found between sensory panel scores for tenderness and Warner-Bratzler shear values. Thus, shear explained 59 percent of the variation in sensory panel scores for tenderness. Correlations of shear value with other variables support the findings of the sensory panel. The correlation coefficient of shear value with fat thickness was 0.44, with marbling score was 0.31 and with carcass grade was 0.33. Since higher shear values indicate less tenderness, these values reveal the same relationships between predicted muscle tenderness and actual tenderness as found by the sensory panel.

Evaporation Loss

The percent evaporation loss of the 6-7-8 rib roasts during cooking was significantly related to palatability. A coefficient of correlation between flavor and evaporation of -.26 was found. Higher relationships were found between evaporation loss and juiciness score ($r = -.56$) and between evaporation loss and tenderness score ($r = -.50$). Greater evaporation losses, therefore, had a deleterious effect upon all measured components of eating quality.

Roasts from carcasses with a thicker fat cover had higher evaporation losses ($r = 0.26$). This was probably because the fatter roasts also were heavier and required more cooking time. The relationship of evaporation loss to carcass grade was not significant.

Drip Loss

Roasts from carcasses with a thicker fat cover tended to have greater drip losses during cooking ($r = 0.64$). Drip loss was negatively related ($P < .01$) to sensory panel juiciness and tenderness scores with coefficients of correlation of -.29 and -.56, respectively. The correlation between drip and flavor ($r = -.18$) was not significant.

Ultrasonic Estimates of Fatness

The relationships between ultrasonic fat thickness estimates and carcass fat thickness were studied separately for each trial since fat estimates were taken a different number of times during the feeding period and the length of time between the last reading and slaughter was not the same in both trials.

Fat measurement correlations generated in trial 1 are presented in Table XXIX. In general, readings taken on consecutive dates were highly related. Readings taken nearer the end of the trial were progressively higher in their relationship to carcass fat thickness. The last ultrasonic measurement of fat thickness, which was taken an average of two weeks prior to slaughter, was highly significant in its relationship to actual carcass fat thickness ($r = 0.88$).

The fat thickness relationships derived from trial 2 data are shown in Table XXX. Readings on consecutive dates were more highly correlated as time on experiment increased and the variability in fatness increased. The correlation coefficient between the ultrasonic estimate of fatness made on the day prior to slaughter and actual carcass fat thickness was 0.84.

The correlations of ultrasonic fat thickness and carcass fatness are higher in both trials than those reported by Stouffer *et al.* (1961), Hedrick *et al.* (1962), Shepard (1964) and Sumption *et al.* (1964). They tend to agree with those found by Watkins *et al.* (1967), who found a correlation of 0.90 between ultrasonically estimated and actual fat thickness.

TABLE XXIX

SIMPLE CORRELATION COEFFICIENTS AMONG UNTRASONIC FAT THICKNESS ESTIMATES AND CARCASS FAT THICKNESS (TRIAL 1)[a,b]

Date of ultrasonic estimate	Carcass fat thickness	Date of ultrasonic estimate			
		5-7-65	4-19-65	3-9-65	2-10-65
1-12-65	0.56	0.68	0.67	0.81	0.91
2-10-65	0.58	0.71	0.76	0.85	
3- 9-65	0.65	0.78	0.82		
4-19-65	0.83	0.92			
5- 7-65	0.88				

[a] Calculated on an overall basis.

[b] Correlation coefficients are based on 34 degrees of freedom. Values of 0.32 and 0.41 are required for significance at the 0.05 and 0.01 levels of probability, respectively.

TABLE XXX

SIMPLE CORRELATION COEFFICIENTS AMONG ULTRASONIC FAT THICKNESS ESTIMATES AND CARCASS FAT THICKNESS (TRIAL 2)[a,b]

Date of ultrasonic estimate	Carcass fat thickness	Date of ultrasonic estimate					
		At slaughter	4-1-66	3-10-66	2-12-66	1-8-66	12-9-65
11-11-65	0.34	0.54	0.46	0.45	0.57	0.35	0.44
12- 9-65	0.52	0.64	0.56	0.66	0.63	0.40	
1- 8-66	0.42	0.41	0.41	0.48	0.42		
2-12-66	0.62	0.79	0.75	0.76			
3-10-66	0.84	0.84	0.90	0.89			
4- 1-66	0.84	0.84	0.91				
At slaughter	0.84	0.84					

[a] Calculated on an overall basis.

[b] Correlation coefficients are based on 47 degrees of freedom. Values of 0.27 and 0.36 are required for significance at the 0.05 and 0.01 levels of probability, respectively.

Correlations of this magnitude lend support to the possibility of employing an ultrasonic device to aid in selection of breeding animals to improve the lean to fat ratio of the carcasses.

In trial 1, simple correlations calculated on a within treatment basis revealed that, in the steers fed alike, there was a significant ($P < .05$) relationship between initial fat thickness and the increase in fat thickness during the feeding period ($r = 0.35$). Average daily gain and initial fatness or the increase in fat thickness were not significantly related on a within treatment basis.

In the second trial, a significant ($P < .01$) simple correlation of 0.43 between initial fat thickness and fat thickness increase was revealed by a within treatment analysis. The relationship between initial fatness and average daily gain was not significant. Steers which had a faster average daily gain had a significantly ($P < .01$) greater increase in fat thickness.

Thus, it appears that a predisposition to fatten may have existed in the steers in this study. Steers with more fat initially had a greater increase in fatness in both trials. Cattle may differ in the relationship of average daily gain to rate of fattening since no relationship between these variables was demonstrated by the cattle in the first trial; but faster gaining steers tended to have a greater fat thickness increase in trial 2. Initial fatness was not significantly related to average daily gain in either trial.

CHAPTER V

SUMMARY

Eighty-four weanling Hereford steers were used in a two-year study of the effects of three pre-determined subcutaneous fat thickness levels upon the production efficiency and organoleptic properties of beef. Three rations, which comprised three treatments (low, medium and high energy levels), were fed to produce a fat thickness over the twelfth rib of 3 to 5 mm., 8 to 10 mm. and 13 to 15 mm. for treatments 1, 2 and 3, respectively, after a 150 to 185-day feeding period. The rate of subcutaneous fat deposition was monitored by ultrasonic methods.

The weanling steers in the first trial came from the University of Tennessee Atomic Energy Commission herd and had feeder grades of Good and Choice. Steers win the second trial were purchased in three East Tennessee feeder calf sales and graded Good and Medium. The steers in trial 1 had a greater initial subcutaneous fat thickness, made slower daily gains and had higher costs of gain. Gains made by trial 2 steers had a more favorable lean to fat ratio than those in trial 1. Trial 1 steers demonstrated an accelerated rate of fattening near the end of the trial, while the faster gaining steers in trial 2 fattened at a more uniform rate. In trial 1, the fat thickness of the steers on the intermediate and high feeding levels fell within the desired range but the low level treatment exceeded the desired level. The trial 2 steers, which fattened more slowly, did not attain the desired fat thickness in treatments 2 and 3 even though the feeding period was extended to 185 days.

Fat thickness over the l. dorsi muscle was significantly ($P < .01$) increased by the rations with higher energy. Fat thickness over the b. femoris muscle was significantly greater for the steers receiving the highest energy level. The high level treatment produced significantly larger l. dorsi and b. femoris muscle areas. Carcass conformation grade, marbling score and carcass grade all were significantly ($P < .01$) increased as level of energy in the ration was increased. Weights of trimmed, partially boneless retail cuts from the round, the loin, the rib and the chuck all were significantly ($P < .01$) increased by higher feeding levels. The percent of the carcass comprising these cuts was significantly lowered by increased ration energy, but the percent of the live weight in these cuts was not significantly affected. Higher feeding levels tended to produce brighter-colored, firmer, finer-textured muscle. Fat color and sensory panel flavor and juiciness scores were not significantly affected by treatment. A tendency for tenderness to decrease as feeding level increased was observed. Treatment 3 had significantly ($P < .01$) lower tenderness scores and higher shear values.

The area of the l. dorsi accounted for but 18 percent of the variation in partially boneless trimmed retail cuts from the round, loin, rib and chuck on a weight constant basis, while b. femoris area accounted for 34 percent of this variation. The weight of the trimmed round was more highly related ($r = 0.92$) to the weight of trimmed retail cuts than was separable muscle of the round ($r = 0.74$).

Carcass conformation was significantly affected by fat thickness with the fatter carcasses tending to receive higher carcass conformation grades (r = 0.62). Fatter cattle had significantly ($P < .01$) higher marbling scores and carcass grade. The relationship between marbling score and carcass grade (r = 0.93) was highly significant.

Fatter carcasses tended to have brighter-colored muscle which was significantly firmer. The relationship between muscle texture and fatness was very low. Muscle color had little or no influence on flavor and a non-significant influence on juiciness. Darker-colored muscle was significantly ($P < .05$) more tender. Muscle texture had no influence on tenderness, juiciness or flavor scores. Firmness of muscle was negatively related to panel tenderness scores but was not related to panel flavor and juiciness scores.

Flavor score was unaffected by marbling score, carcass grade or fat thickness. Juiciness scores were not significantly related to carcass grade, marbling score or fat thickness. Significant ($P < .01$) negative relationships were found between tenderness and marbling score, carcass grade and fat thickness. The shear values obtained from one-half-inch cores substantiate the sensory panel's evaluation of this major contributor to the eating quality of beef. The correlation coefficient between panel tenderness score and shear value was -.77.

Ultrasonic estimates of fat thickness taken before slaughter were highly related to carcass fat thickness. The correlation between the ultrasonic estimate and the actual fat thickness of the carcass was 0.88 for trial 1 and 0.84 for trial 2.

Results of this study indicate that acceptable beef may be produced with little waste fat. Although marbling score, carcass conformation and carcass grade all were significantly increased by increased fat deposition, tenderness, juiciness and flavor were not enhanced by increased fatness.

Ultrasonic estimates of fat thickness and actual carcass fatness were highly related. Thus, the use of ultrasonics to select breeding animals with the genetic potential to reduce the overall fatness of the beef cattle population is implicated. Results of this study using Hereford steers indicate that this may be done without jeopardizing beef eating quality.

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In September, 1956, he entered the University of Tennessee to pursue a Master's degree program in Animal Husbandry with an emphasis on meats. He received his Master's degree from U.T. in June, 1958.

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