EFFECT OF LENGTH OF FATTENING PERIOD ON MUSCLE DEVELOPMENT OF THE BEEF ROUND AND EVALUATION OF VARIOUS CRITERIA OF CARCASS MUSCLING

by

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INTRODUCTION

The data reported and discussed in this thesis includes only a part of a large research project dealing with the development of carcass traits and possible changes in carcass relationships which occur when beef steers are fed for increasing periods of time. This thesis examines the changes in relationships of: 1) various carcass measurements to established indicators of retail yield, 2) carcass measurements, muscle weights, and muscle areas to the retail yield of various sections of the beef round, and 3) carcass measurements to muscle weights of the round and the longissimus dorsi.

Much research work has been done in trying to establish reliable predictors of retail yield from beef carcasses. Using some of the most accepted indicators as endpoints of retail yield, this thesis examines correlation coefficients between various carcass measurements and retail yield predictors in an attempt to find several measurements which may be satisfactory in predicting retail yield of a calf carcass as well as a fat steer carcass. The trends or patterns of the correlation coefficients which are established during the fattening period are of importance in determining the reliability of using various carcass measurements in predicting the retail yield of beef carcasses after varying periods of full feed.

The second section covered by this thesis is the prediction of the retail sections of the round by the use of various round measurements, muscle weights, and muscle areas. Information leading to the development of specifications for beef rounds which would yield a determined amount of each retail cut may be helpful to the meat industry. Some information may be gained in this area by the analysis of relationships which exist in the beef round data collected in this study. Limited information in the literature points to a need for work in this area.

Muscle development of the beef steer during the fattening period was studied. The examination of the correlation coefficients between the round muscle weights and the various round measurements, plus a look at the areas and weights of the round muscles with respect to the stage of fattening may help to bring together a true picture of beef round development.

LITERATURE REVIEW

Many carcass measurements have been studied in beef cattle in an attempt to find some measurement which will accurately estimate the yield of usable meat from the beef carcass. In studying the relationships between carcass measurements and yield, the time and labor available dictates what a researcher may use as an endpoint in measuring the edible portion. The ultimate would be a complete physical separation of the carcass, but few have the time and/or the labor for the task. Many carcass measurements, weights, percentages, and formulas have been studied and used in the evaluation of the edible portion of the beef carcass.

Yield Prediction Formulas

One of the many possible endpoints of carcass yield is the set of regression equations developed by Murphy et al. (1960). Their equations have been widely used in determining the cutability of beef cattle. In their work they evaluated 450 carcasses which ranged in carcass grade from standard to prime. They found simple correlation coefficients of 0.81 and 0.79 between the boneless retail yield and average of three fat thickness measurements over the rib eye and a single fat thickness measure, respectively. They reported a correlation of .79 between the yield of the major wholesale cuts and the boneless retail yield and a correlation of .98 between bone-in and boneless retail yields. Finish was four and one-half times as important as conformation in predicting yields of trimmed, mostly bone-in retail cuts from the round, loin, rib, and chuck. They concluded from their work that a most useful tool for predicting the boneless retail cuts from the round, loin, rib, and chuck was an equation using fat thickness over the rib eye at the twelfth rib, carcass weight, percent kidney fat, and rib eye area.

Brungardt and Bray (1963) developed a formula to predict percent retail yield of beef carcasses. The formula was based on work they had completed using thirty-three sides of U.S.D.A. Choice beef divided into three weight groups. The range in the left side weights of their three groups was 260-288 pounds, 300-325 pounds, and 332-360 pounds. They found that the percent trimmed round and a single twelfth rib fat measurement accounted for 81 percent of the variation in the percent retail yield. They developed the following prediction equation: $Y = 16.64 + 1.67X_1 - 4.94X_2$ where Y = percent retail yield, X_1 = percent trimmed round, and X_2 = single fat measurement over the twelfth rib. The fat thickness measurement is easy to obtain without breaking or altering the carcass, but the carcass must be broken to get the weight of the trimmed round.

Separable Lean from 9-10-11 Rib Cut

The physical composition of the 9-10-11 rib cut has been widely used for years as an indicator of the composition of the entire carcass. Hankins and Howe (1936) stated that the physical composition of the 9-10-11 rib appeared to be satisfactory for estimating the fatness of an animal. They gave formulas for estimating both the separable fat and separable lean of the entire carcass based on the lean and fat information obtained from the physical separation of the 9-10-11 rib cut. Their work had shown high relationships between the physical composition of the whole carcass and the physical composition of the 9-10-11 rib cut.

Hopper (1944) found that the physical composition of the wholesale rib, the edible portion of the wholesale rib, and the physical composition of the 9-10-11 rib were highly correlated with the physical composition of the entire carcass and with the edible portion of the entire carcass.

Crown and Damon (1960) studied the 9-10-11 rib as an indicator of carcass composition on seventy-three purebred and crossbred cattle. The carcasses averaged 443 pounds and graded from standard to prime. Their correlation coefficients for percentages of separable lean and fat of the 9-10-11th rib cut with the dressed carcass separable lean and fat were .943 and .976, respectively.

Hedrick et al. (1963) conducted a beef carcass study involving 210 head of steers and heifers, ranging in weight from 666 to 1310 pounds and in grade from low standard to low prime. They reported a highly significant correlation coefficient of .69 between the percent total lean of the 9-10-11 rib cut and the yield of the primal cuts.

Cole et al. (1960) reported a correlation coefficient of .74 between separable lean of the 9-10-11 rib cut and separable lean of the carcass. This work was done with eighty-one steers, nine heifers, and nine cows grading from U.S.D.A. Choice to Utility. Sixty-three of the steers were slaughtered when they reached 900 pounds or twenty months of age, while the remainder of the eighty-one were purchased as 500 pound carcasses.

Cole et al. (1960) found that the 9-10-11 rib cut lean was significantly correlated with rib eye area at the twelfth rib ($r = .55$) and with carcass weight ($r = .57$).

Cole et al. (1959) found a correlation coefficient of .547 between rib eye area and separable lean of the 9-10-11 rib cut. In this study he used fifty steers, nine cows, and nine heifers of British, Brahman and large and small dairy breeding.

Kropf (1959) conducted a study on certain muscle and bone characteristics in beef carcasses. He used twenty-nine beef carcasses grading from high standard to high good. He found a significant relationship (r = .41) between the percent separable lean of the 9-10-11 rib and the rib eye area per 100 pounds carcass weight.

Woodward et al. (1959) reported that fat thickness over the rib eye (average of three measurements) was correlated (r = .32 and .54) with the weight of the separable lean and the weight of the edible portion of the 9-10-11 rib, respectively. He reported that a low nonsignificant correlation existed between the rib eye area and the percent lean from the 9-10-11 rib cut.

Weights and Percents as Yield Indicators

The weight of the trimmed wholesale cuts, the weight of the four primal cuts, the weight of the separable lean from the carcass, and percentages of each of these have been used as endpoints for carcass value. Cole et al. (1962) used 132 steer carcasses, ranging in weight from 301 to 567 pounds, of various breeds and types in a study to determine the value of the rib eye area, fat thickness, and carcass weight for predicting the separable lean in a carcass. He used pounds of separable lean rather than percent separable lean in his statistical analysis. Carcass weight was more highly associated with pounds of separable lean (r = .75) than any other single measurement he studied. Carcass weight alone was more closely related to separable lean than were combinations of carcass length and rib eye area at the twelfth rib, or carcass length, rib eye area at the twelfth rib, and fat thickness over the twelfth rib. A combination of rib eye area and carcass weight had no advantage to offer over carcass weight alone. When carcass weight was held constant, rib eye area was associated with only five percent of the variation in pounds of separable lean. The average of three fat thickness measurements over the twelfth rib was only weakly related to pounds of lean in the left side of the carcass (r = .07). Fat thickness at the twelfth rib was correlated (r = .53) with carcass weight. In an attempt to get a volume measure, the product of carcass length and the average area of the rib eye at the fifth rib, the twelfth rib, and last lumbar was correlated with separable lean. The simple correlation coefficient was .73. A combination of carcass length and carcass weight gave a significant correlation (r = .80) with pounds of separable lean. When fat thickness was added to the combination the correlation coefficient was .84. Adding rib eye area at the twelfth rib to the three other measurements raised the correlation coefficient to .85. They concluded that the most valuable prediction equation for pounds of separable lean is one which included carcass weight and fat thickness. These two measures were associated with over seventy percent of the variation in pounds of separable lean and both measurements were obtained quickly and easily without destruction of any part of the fore or hind quarters.

Birkett (1963) and Hedrick <u>et al</u>. (1963) used both the weight and percent of the four primal cuts (chuck, rib, loin, and round) to evaluate various carcass measurements. Birkett used sixty-five Hereford steers that ranged in live weight from 855 to 1225 pounds with an average carcass weight of 616 pounds. These steers had been on full feed for 140 days after being wintered on a concentrate-roughage growing ration. Birkett found highly significant correlation coefficients of .802, .763, .511 and .723 between the weight of the four trimmed primal cuts and the circumference of the round at 40, 50, 60 and 70 percent of the distance from the hock joint to the anterior edge of the aitch bone. Length of the hind leg was associated with the weight of the primal cuts (r = .772), while area of the eye at the twelfth rib and carcass weight showed correlation coefficients of .487 and .966, respectively, with the weight of the trimmed four primal cuts. Birkett studied both the average fat thickness and a single fat thickness measurements over the rib eye and found nonsignificant correlations with the weight of the four primal cuts. Hedrick used 210 cattle, both steers and heifers, ranging in grade from low standard to low prime and ranging in live weight from 666 to 1310 pounds. Weight of the primal cuts was correlated with the following carcass measurements: rib eye area at the twelfth rib (r = .41), average of three fat thickness measurements at the twelfth rib (r = .35), length of hind leg (r = .50), circumference of round (r = .46), and carcass weight (r = .86). Carcass weight was the most highly significant.

Birkett (1963) found nonsignificant correlation coefficients between the percent primal cuts and the circumference of round measurements. Rib eye area was correlated (r = .003) with the percent primal cuts and length of the hind leg showed a negative correlation coefficient of .072 with the percent primals. Carcass weight was significantly correlated (r = -.520) with the percent four primal cuts while the correlation of fat thickness measurements to the percent primal cuts was nonsignificant. Hedrick found highly significant correlations between percent primal cuts and carcass measurements. The average fat thickness over the rib eye and carcass weight were negatively correlated (r = -.59) with the percent four primal cuts. Rib eye area, length of hind leg and circumference of round were correlated (r = .28, -.33 and 0.30) respectively, with the percent of the primal cuts.

Goll et al. (1961b) used thirty steer carcasses from each of three U.S.D.A. grades, Standard, Good and Choice in a carcass measurement study. Within each of the three grades, ten carcasses in each of three weight ranges, 430-470, 530-570, and 630-670 pounds were used. He found that circumference of round gave the highest correlation of any carcass measurement with percent "thick" cuts (wholesale chuck, rib, loin, and round) (r = -.42). The percent "thick" cuts was correlated with length of hind leg (r = .22), width of round (r = -.05), and rib eye area at the twelfth rib (r = .00). When the effect of weight was removed, his correlation between percent "thick" cuts and rib eye area was still low and nonsignificant (r = .14). He found that all physical measurements which reflect differences in absolute size and weight had highly statistically significant and positive correlations with carcass weight. Carcass weight was correlated with the length of hind leg (r = .67), with circumference of round (r = .55), with width of round (r = .72) and with rib eye area (r = .52). Percent round and percent "thick" cuts showed correlation coefficients of 0.32 and 0.22, respectively, with carcass weight. The longissimus dorsi area at the twelfth rib showed correlation coefficients of .39 with length of hind leg, .19 with circumference of round, and .45 with width of round. Goll stated that wider, thicker, deeper carcasses yielded a higher percent of "thick" cuts than did carcasses that were less thick, deep and wide.

In another study Goll et al. (1961a) found that weight had a greater influence than grade on carcass measurements such as length of body, length of hind leg, width of round, and rib eye area while carcass grade had a greater influence than weight on yields of cuts. In this study Goll used ninety carcasses divided into three weight groups, 430-470, 530-570 and 630-670 pounds, with carcass grade ranging from U.S.D.A. Standard to Choice.

Orme et al. (1959) obtained carcass data on thirty-one long yearling Angus and Hereford steers which averaged 856 pounds at slaughter with a range in live weight from 780 to 932 pounds. He found that the percent untrimmed primal cuts was highly significantly, but negatively correlated with width of round (r = -.44) and nonsignificantly correlated with the circumference of round (r = -.16). In this same study the rib eye area showed correlation coefficients of .48 and .09 with width and circumference of round respectively. Rib eye area was significantly correlated with the percent primal cuts (r = -.51).

In another study Cole et al. (1960) used eighty-one steers, nine heifers, and nine cows. Sixty-three of the steers included Angus, Hereford, Brahman, Brahman-British crosses and dairy steers which were slaughtered when they reached a live weight of 900 pounds or reached an age of twenty months. The remaining carcasses were purchased according to sex, grade, and weight (500 pounds). Carcass grade in the study ranged from choice to standard and also included commercial and utility. The weight of the separable carcass lean was correlated with length of hind leg (r = .53), with round circumference (r = .45), with round width (r = .06), and with the rib eye area at the twelfth rib (r = .43). He found that a product of rib eye area and carcass length was more highly related to total separable lean than either item alone (r = .55). He stated that the separable lean of any beef cut is a better predictor of total carcass lean or muscling than is rib eye area. He found that with each 1.0 pound increase in the separable lean of the round there was a corresponding increase of 2.94 pounds in the separable lean in a side of beef.

In a similar study Cole et al. (1959) found a correlation coefficient of .956 between the separable lean from the round and the total separable lean from the carcass. In this case, separable lean of the round was associated with ninety percent of the variation in total separable lean of the carcass. In this same study rib eye area was correlated with carcass lean (r = .454) and with the lean in the wholesale round (r = .409).

Ramsey et al. (1962) using 133 steers of both beef and dairy types found that neither carcass grade nor yield grade was superior to a single fat thickness or an average of three fat thickness measurements over the rib eye as an estimator of percent separable lean and fat in the carcass. The average of the three fat thickness measures over the rib eye showed a slightly lower relationship to separable carcass lean than the single fat measurement. He found no advantage of using the average fat measurement over the single measurement for prediction of separable lean. When rib eye area was omitted from yield grade calculations in his study, the resulting yield grades were more highly related to separable lean than when rib eye area was included.

Gottsch (1962) collected data on thirty-eight Hereford steers that averaged 1046 pounds at slaughter time and ranged from 912 to 1236 pounds. Rib eye area was significantly correlated with total carcass lean weight (r = .42) while the rib eye area per cwt. chilled carcass was highly significantly correlated with the weight of the total lean from the carcass (r = .59). The weight of the lean from the round was highly significantly correlated with rib eye area per cwt. chilled carcass (r = .45) and non-significantly correlated with the rib eye area at the twelfth rib.

In working with forty-eight Hereford steers averaging 1298 pounds, Dunn (1960) found a highly significant correlation coefficient of .76 between the trimmed round weight and the weight of the trimmed wholesale cuts. Loin eye area per hundred pounds of carcass was correlated with the trimmed round (r = .39). He stated that the trimmed round was a more important measure of total trimmed wholesale cuts than the loin eye area of the twelfth rib.

Beef Round Yield

Research work has been done on the beef round in an attempt to predict its yield as part of the carcass and in an attempt to predict retail cuts and muscle weights from the round. The longissimus dorsi is included in much of the research work done with muscle weights.

Green et al. (1955) found a correlation coefficient of .91 between slaughter weight and weight of the round. Goll et al. (1961a) stated that the percent yield of the round decreases as carcass weight increases. Hedrick et al. (1963) found highly significant correlation coefficients of .54 and .47 between weight of the trimmed round and two round measurements, length of hind leg and circumference of round, respectively. Birkett (1963) worked with relationships between carcass measurements (especially those involving the round) and the weight of the trimmed round. He found the weight of the trimmed round to be highly significantly correlated with various round circumference measurements (r = .885, .816, .535, and .781 for round circumference measurements at points 40, 50, 60 and 70 percent of the distance from the hock joint to the anterior edge of the aitch bone), non-significantly correlated with fat thickness over the rib eye at the twelfth rib, and highly significantly correlated with length of hind leg (r = .758), rib eye area at twelfth rib (r = .534) and carcass weight (r = .886). Goll et al. (1961b) found that the width of the round was more highly related to yield of round than either length of hind leg or circumference of round.

In his study, percent round was negatively correlated with rib eye area at the twelfth rib (r = -.09).

Field et al. (1963) studied carcass characteristics on 207 bulls, 72 heifers, and 233 steers of four different breeds weighing 200-799 pounds. Depth of round, a measurement of the consumer-demanded portion of the round, was correlated with carcass weight, length of body, and rib eye area at the twelfth rib (r = .94, .92, and .71 respectively). Circumference of round had a much lower correlation coefficient with carcass weight, length of body, and rib eye area than with depth of round. Backus et al. (1960) found that length of hind leg was highly significantly correlated with circumference of round, and that circumference of round was highly related with rib eye area, rib eye length, and width of round.

Thornton and Hiner (1963) used 104 beef and dairy steers in a round muscle volume study. They made three linear measurements (length from aitch bone to hock, thickness of round, and width of round) and transformed them into a volume. This calculated round volume was highly correlated with actual round weight (r = .95) and with the carcass lean weight (r = .94). In their study the weight of the round was highly correlated with the weight of the carcass lean (r = .98). They found that breed differences in shape of round were statistically significant.

Round Muscle Areas

Boughton (1958) used round muscle areas of thirty Hereford steers and fifty-three Hereford heifers in an attempt to estimate the percent rump and percent commercial round. The steers ranged in live weight from 800 to 1100 pounds, and the heifers varied from 685 to 880 pounds in live weight. The rump was removed from the commercial round and the exposed surfaces of the semimembranosus (SM), semitendinosus (ST), and biceps femoris (BF) were traced on the round portion. The rib eye area at the twelfth rib was also used in the study. Boughton found that the area of the SM was highly correlated with percent rump in steers (r = .44), with percent rump in heifers (r = .57), and with the rib eye area in heifers (r = .32). It was negatively and nonsignificantly correlated with percent commercial round of the steers and heifers, and with the rib eye area of the steers. The area of the ST was highly significantly correlated with the percent rump of the heifers (r = .57) and with the rib eye area of the heifers (r = .38). It was nonsignificantly related to the percent commercial round of both the steers and the heifers, percent rump of the steers, and rib eye area of the steers. The area of the BF was highly statistically related to the percent commercial round of the heifers (r = .36) and to the rib eye area of the steers (r = .48). It was not significantly related to the percent rump of both the heifers and the steers, the percent commercial round of the steers, and the rib eye area of the heifers. The area of the longissimus dorsi was significantly correlated with the percent rump of the heifers (r = .32) and nonsignificantly correlated with the percent commercial round of the steers and heifers and the percent rump of the steers. When this data was corrected for live weight, not much change was observed in the level of significance of the previously mentioned relationships.

Muscle Weights

Orme et al. (1960) studied the weights of individual muscles and muscle groups on forty-three mature Hereford cows. They ranged in age from eight and one half to eleven years, in live weight from 825 to 1410 pounds, and in grade from high cutter to high commercial. Average muscle weights were as follows: longissimus dorsi (LD) - 10.97 pounds; biceps femoris (BF) - 10.49 pounds; semitendinosus (ST) - 3.72 pounds, inside round muscle group - 10.45 pounds, and sirloin tip muscles - 8.87 pounds. Carcass weight was calculated to have correlation coefficients of .83 with LD weight, .83 with BF weight, .73 with ST weight, .75 with inside round weight, and .70 with sirloin tip weight. All these correlations were highly significant. He found that these muscle weights were highly correlated with separable carcass lean. He concluded that certain entire muscles and muscle groups could be used to estimate degree of muscling in the mature beef carcasses.

Orme (1958) found that the weight of ST was not highly correlated with the rib eye area at the twelfth rib. Orme et al. (1959) presented a significant correlation coefficient of .40 between rib eye area and percent semitendinosus. Woodward et al. (1959) found a simple correlation coefficient of .67 between rib eye area at the twelfth rib and the weight of the longissimus dorsi. Field (1963) reported a highly significant correlation coefficient of .97 between depth of the consumer preferred portion of the round and the total weight of five dissected muscles (longissimus dorsi, semitendinosus, supraspinatus, infraspinatus, and forearm muscles).

Carcass and Muscle Development

Luitingh (1962) conducted a study to observe development changes in beef steers as influenced by fattening, age, and type of ration. He was interested in (1) changes in carcass proportions during fattening due to age and ration, (2) relative increases of body parts during fattening at different ages, and (3) the developmental patterns of beef steers of different ages during fattening. He used forty-eight steer calves, forty-seven two-year-olds, and forty-five three-year-olds. The cattle were randomly divided and fed three different rations which were merely variations in the concentrate-roughage ratios. In his work the weight of the buttock and rump were recorded as a single weight. The buttock-rump was the next to the slowest growing part of the steers under fattening conditions. This section of the carcass formed a significantly lower percent of the carcass of the fattened steers than of the unfattened steers. No significant differences were found in the proportion of buttock-rump of the carcass due to ration or age of the animal. The percentage change of buttock-rump tended to be directly proportional to change in live weight. The difference between the correlation coefficients of the unfattened and fattened groups was not significant in the case of the buttock-rump correlated with live weight. Steers fed the high concentrate ration showed the greatest percent increase in the circumference of buttock of the ration groups, while the two-year-old steers showed the greatest percent increase of buttock circumference of the age groups.

Zinn (1963) conducted an experiment using 100 steers and 100 heifers to evaluate muscle growth during the feeding period. All cattle in the experiment were fed identical rations. Ten head of steers and ten head of heifers were slaughtered every thirty days with the remainder staying on feed each time. The control lot which were killed at the beginning of the experiment had a significantly greater percent of boneless primals than those fed 270 days.

MATERIALS AND METHODS

History of the Animals

Sixty-four Angus steers sired by Bardoliermere 100th amd owned by Martin K. Eby, Wichita, Kansas, were used in the study. The calves were born in the fall of 1962 starting in mid-October, vaccinated and castrated in February of 1963, and run on grass with their mothers until weaning on June 14, 1963. They received no creep feed from birth until weaning. On June 15, 1963, the steers were trucked to the Deets Feed Yard, Fredonia, Kansas, where they were individually identified and randomly divided into eight groups.

Group I was shipped to Kansas City for slaughter, and groups II-VIII were placed in the Deets Feed Yard. Groups II-VIII were fed in one lot with a self-feeder containing a full feed ration using milo as the main concentrate and cottonseed hulls as the main roughage. Group II was removed from the feed lot and slaughtered fifty-six days post-weaning, Group III at eighty-four days, Group IV at 112 days, Group V at 140 days, Group VI at 168 days, Group VII at 196 days, and Group VIII at 224 days.

Slaughter and Chilled Carcass Data

Once the animals left the Deets Feed Yard all data was collected in the same manner. Each group was shipped to Kansas City and consigned to the Maurer-Neuer Division of the John Morrell Packing Company. Individual slaughter weights were taken at the Kansas City Union Stockyards by a weigh master of the Stockyards Company. The steers were slaughtered by Maurer-Neuer using standard approved packing plant procedures. Identification numbers were placed on the carcasses on the kill floor so proper identification could be made in the cooler. Hot carcass weight was taken before carcasses were placed in the cooler.

Approximately twenty-four hours following slaughter, chilled carcass measurements were made. Chilled carcass weight was taken. All measurements were taken on the right side of the carcass except the width measurements which were averages of both sides to minimize variation due to carcass splitting. Length of hind leg or length of round was measured from the anterior edge (lowest point) of the aitch bone to the highest point on the tarsal bones in the hock joint. Length of the thoracic-lumbar portion of the vertebral column was measured from the anterior edge of the first thoracic vertebra to the posterior edge of the last lumbar vertebra. Six circumference of round measurements were taken. These were taken at points located 40, 50, 55, 60, 70 and 75 percent of the length of the hind leg with 40 percent being closest to the shank end of the round. Shroud pins were placed on sides of the round to hold the tape at an equal distance down from the hock while the measurement was being made. Width of round and width of round (dorsal), were measured with a set of calipers. The width of round measurement was made at the highest point of the aitch bone through the round, keeping the carcass at right angles to the calipers. Width of round (dorsal) was made directly above the anterior edge of the aitch bone and just below the fat collar of round through the round. This measurement appears to approximate the width through the thickest and center part of the round. Figure 1 shows skeletal reference points of the round measurements. The shank circumference was measured at a point one half of the way between the elbow and the lowest point of the foreshank.

The cross-sectional area of the longissimus dorsi was traced between the 12th and 13th ribs and measured with a compensating polar planimeter. Fat

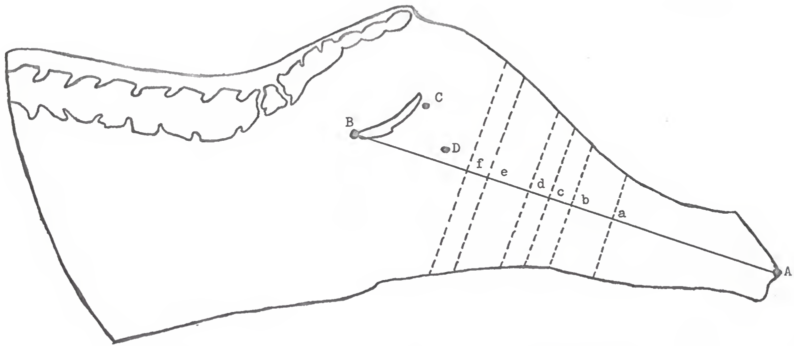

Figure 1. Skeletal reference points of round measurements.

A to B	Length of hind leg
C	Point through which width of round measured
D	Point through which width of round (dorsal) measured
a	Circumference of round at 40% length of hind leg
b	Circumference of round at 50% length of hind leg
c	Circumference of round at 55% length of hind leg
d	Circumference of round at 60% length of hind leg
e	Circumference of round at 70% length of hind leg
f	Circumference of round at 75% length of hind leg

thickness over the 12th rib was measured 1/4, 1/2, and 3/4 of the cross sectional length of the longissimus dorsi from the medial edge and recorded both as an average of three measurements and as a single measurement 3/4 of the distance from the chine bone end of the eye to the lateral end of the eye.

All carcasses were graded by a grader of the Federal Grading Service. All carcasses were ribbed prior to grading.

Laboratory Procedure

The right side of each carcass was shipped to the Meat Laboratory, Kansas State University where further carcass information was obtained. Each side was weighed just prior to cutting. The forequarter was broken into the chuck, brisket, foreshank, plate, and rib, and the weights were recorded to the nearest one-tenth pound. The chuck and rib were trimmed to 3/8 inch external fat and a trimmed cut weight was recorded. The 9-10-11th rib cut was physically separated into lean, fat, and bone, and the weights were recorded to the nearest gram. The longissimus dorsi was dissected from the chuck and remaining section of the rib. These sections plus the longissimus dorsi was removed from the loin and weighed on a gram scale. The rump was removed from the round by cutting parallel to and immediately ventral to the aitch bone. The surface exposed by this cut will be designated as the round removal surface (RS) in all further procedures and data. The semimembranosus (SM), biceps femoris (BF), and semitendinosus (ST) were dissected from the rump. The areas of the SM, ST, and BF were traced on the round removal surface. Another cut was made parallel to the RS and through a point seventy-five percent of the distance from the highest point on the tarsal bones in the hock joint to the anterior edge (lowest point) of the aitch bone. The surface exposed by this cut will be known as the seventy-five percent surface (75%). The areas of the SM, ST, and BF were traced on this surface. The six areas were later measured with a compensating polar planimeter. The SM, ST, and BF were dissected from the round and along with their components from the rump were weighed and recorded to the nearest one-tenth pound. Figure 2 shows the individual round muscles which were traced and dissected. The round, excluding rump, was then divided into the boneless retail cuts of the top round, bottom round, sirloin tip, and heel of round. The SM, ST, and BF of the round were included in their respective retail cuts. The cuts were weighed and recorded to the nearest one-tenth of a pound.

Statistical Analysis

The data collected were analyzed on a within group basis. Simple correlation coefficients were obtained between all variables studied. In addition, simple correlation coefficients were obtained between all variables and calculated values for the weight of the four trimmed lean cuts, the percent trimmed four lean cuts, the Brungardt-Bray round prediction formula [percent retail yield = 16.64 + 1.67 (percent trimmed round) - 4.92 (single fat measurement over twelfth rib)], and a U.S.D.A. regression equation [percent boneless retail cuts from the round, loin, rib, and chuck = 52.56 - 4.95 (single fat measurement over twelfth rib) - 1.06 (percent kidney fat) + 6.82 (rib eye area) - .008 (carcass weight)]. According to Snedecor (1956) correlations coefficients of .71 and .83 are required for significance at the .05 and .01 levels when eight observations are made within each group. Significance in this thesis applies to the population of this study, not directly to all beef animals on feed for varying periods of time.

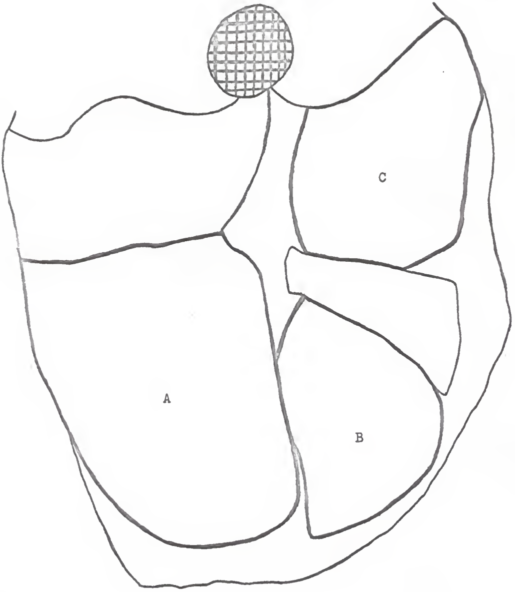

Figure 2. Cross-section of individual round muscles measured.

A Semimembranosus

B Semitendinosus

C Biceps femoris

RESULTS AND DISCUSSION

Gross Carcass Data

Group averages and ranges for slaughter weight and hot carcass weight are presented in Table 1. The average weight increase between groups or average daily gain did not vary much throughout the feeding period, ranging from 2.34 pounds a day for the first fifty-six days on feed to 2.47 pounds a day for the period between 168 and 196 days on feed. Average dressing percentage based on the hot carcass weight ranged from 54.4 percent for group I to 64.0 percent for group VI.

All carcasses in group I were classified as calf carcasses. Figure 3 shows part of the carcasses in group I. Seven carcasses in group I graded U.S.D.A. Good Calf and the other carcass graded U.S.D.A. Standard Calf. In group II one carcass was classified as beef and graded U.S.D.A. Good on the beef standards. The remaining seven carcasses of the group were classified as calf and graded U.S.D.A. Good according to the calf standards. In group III six of the eight carcasses classified as beef and were given a beef grade of U.S.D.A. Good. The other two carcasses classified as calf and were the calf grade of U.S.D.A. Good. All carcasses in groups IV through VIII were classified as beef and were graded according to the beef grading standards. This data shows that with steers handled as these were it takes 296-324 days of age and fifty-six to eighty-four days of feed for their carcasses to obtain enough maturity to be classified as beef.

One carcass in each of group IV and group V graded U.S.D.A. Choice, while the remaining seven carcasses in each group graded U.S.D.A. Good. In group VI there were two U.S.D.A. Choice grading carcasses and six carcasses which graded U.S.D.A. Good. The carcass grade picture changed in groups

Table 1. Group averages and ranges for slaughter and carcass weights.

Group No.	I	II	III	IV	V	VI	VII	VIII
Days on feed	0	56	84	112	140	168	196	224
Average slaughter weight (pounds)	351	447	493	525	631	682	785	835
Range in slaughter weight (pounds)	305-405	370-575	400-593	425-630	540-715	570-795	665-875	770-915
Average hot carcass weight (pounds)	190	258	302	334	401	437	498	529
Range in hot carcass weights (pounds)	166-221	207-341	246-358	258-410	339-485	370-516	400-560	490-594

Figure 3. Four of the group I carcasses.

VII and VIII. Seven of the eight carcasses in each group graded U.S.D.A. Choice while only one carcass in each group remained in the U.S.D.A. Good grade. Figure 4 shows part of the carcasses in group VIII. There was no further improvement in carcass grade from 196 days on feed to 224 days on feed, but it appears that steer calves in this study raised without creep feeding which have been full fed from weaning until slaughter require at least 196 days of feed to make the U.S.D.A. Choice grade.

Carcass Measurements and Established Indicators of Carcass Retail Yield

The total weight of the trimmed four primal cuts, i.e., chuck, rib, loin and round (rump on), was correlated with various carcass measurements. Slaughter weight was highly significantly correlated (1% level of significance) with the weight of the trimmed four primal cuts in all groups except in group VIII where the correlation (r = .78) was significant at the 5% level. Carcass weight was highly significantly correlated with the weight of the primal cuts in all groups. As was the case for slaughter weight, the correlation (r = .83) for carcass weight in group VIII was lower than the correlations in the other seven groups. This may be due to the fact that no group of carcasses required trimming (retail trim of the retail cuts) until groups VII and VIII. The average fat trim in group VII was 1.16 percent and increased to 1.98 percent in group VIII. The lowered correlations for group VIII might be explained by the fact that slaughter and carcass weights measure the total or whole of the steer and carcass respectively, while the weight of the four primals was a trimmed weight.

The high correlation coefficients between carcass weight and the weight of the trimmed four primal cuts are in agreement with those presented by other workers. Cole _et al_. (1962) stated that carcass weight was more

Figure 4. Four of the group VIII carcasses.

highly related to the weight of the four primal cuts than any other variable studied. With a range in carcass weight from 301 to 567 pounds, his work would be comparable to groups IV through VIII. Hedrick <u>et al</u>. (1963) also found that carcass weight was highly significantly correlated with the weight of the four primal cuts.

The correlation coefficient between the length of the hind leg and the weight of the trimmed four primal cuts ranged from .97 in group II to .81 in group VII. Another length measurement, length of vertebral column, was not as highly related to the weight of four lean cuts as the length of the hind leg, although group VI had a correlation coefficient of .94. Birkett (1963) found a highly significant correlation (r = .772) between length of hind leg and the weight of the trimmed four primal cuts. Results presented in this thesis agree with this finding, but also point up the fact that the length of the hind leg is highly related to the weight of the trimmed four primal cuts in earlier stages of growth and fattening. The circumference of round measurement correlations showed no specific trends. The circumference of round measurements were considerably lower in group VIII than for any other group. Circumference of round was a much better predictor of the weight of the primals in the first feeding group as compared to the last feeding group. This may be due to the influence of fat accumulation on the round surface. The group I carcasses were almost devoid of fat on the round, while the group VIII carcasses had a sizeable fat collar which may have increased the circumference measurement. Results of circumference of round measurements reported here are in disagreement with similar work by Birkett (1963). Birkett also measured circumference of round at various points on the round. His correlation coefficients with the weight of the four primal cuts were highly significant while those reported here are lower and more variable. There may be a breed difference which shows up in these two studies, plus the fact that the cattle used in the Birkett study had a much larger range in weight.

There was no pattern of significance for the width of round or width of round (dorsal) measurements when correlated with the weight of the trimmed four primal cuts. The rib eye area at the 12th rib was highly significantly related to the trimmed weight of the primals in groups V and VI, but generally the correlation coefficients were low and nonsignificant. The rib eye area at the 12th rib, apparently has been given more than its share of emphasis as an indicator of carcass muscling according to the results presented here. This is substantiated by Cole et al. (1962) who reported that rib eye area at the 12th rib accounted for only five percent of the variation in the weight of the primal cuts when carcass weight was held constant.

Fat thickness measurements, both an average of three and the single lateral measurement, were not significantly related to the primal cut weight except in group VI where the average measurement was highly significantly related ($r = .87$) and the single measurement was significant at the five percent level ($r = .77$). This generally agrees with Cole et al. (1962) and Birkett (1963) who found that there was only a weak relationship between fat thickness measurements and the weight of the trimmed four primal cuts.

The correlation coefficients of shank circumference with the trimmed primal cut weight were low and nonsignificant in groups I, II, VII, and VIII, while in the four middle groups, or those groups on feed from 84 to 168 days, the circumference of the shank appeared to be of benefit in estimating the weight of the trimmed four primal cuts.

Correlation coefficients between the weight of the trimmed four primal cuts and various carcass measurements appear in Table 2. The effect of the length of the feeding period on the relationships between the weight of the trimmed primal cuts and carcass measurements appears to be varied when you look at the results by feeding periods or groups. The correlation coefficients for group VI or the group which had been fed for 168 days were consistently the highest among all groups. Most correlation coefficients of this group were either significant at the five or one percent levels of confidence while the correlation coefficients of other groups were generally lower and more variable. These results indicate that the accuracy of carcass measurements in estimating the weight of the trimmed primal cuts may be the highest after steers have been fed to a point where they are fat, but not exceeding a degree of finish where their carcasses need a fat trim of the primal cuts.

The percent trimmed four primal cuts, the Brungardt-Bray round prediction formula, and the U.S.D.A. regression equation were correlated to various carcass measurements. Correlation coefficients between these three value predictors and carcass measurements were generally negative, low, and nonsignificant. Tables 3, 4 and 5 present values for these correlation coefficients.

The percent trimmed four primal cuts was obtained by dividing the weight of the trimmed four primal cuts by the chilled carcass weight. No specific carcass measurement appeared superior for the prediction of carcass value when value was measured in terms of percent primal cuts. When the correlation coefficients were analyzed in terms of group superiority, no one group or feeding period can be said to be most accurate time to use carcass measurements to predict the percent four primal cuts.

Table 2. Simple correlation coefficients between the weight of the trimmed four primal cuts and various carcass measurements.

Group Number	I	II	III	IV	V	VI	VII	VIII
Slaughter weight	.88**	.98 **	.97 **	.98 **	.96**	.97**	.94**	.78*
Carcass weight	.98**	.998**	.997**	.996**	.98**	.99**	.98**	.83**
Length hind leg[a]	.86**	.97 **	.89 **	.88 **	.84**	.87**	.81*	.83**
Length vert. column[b]	.76*	.61	.84 **	.89 **	.78*	.94**	.52	-.04
Circ. of round[c] - 40%	.86**	.81*	.62	.83 **	.72*	.70	.55	.25
50%	.82*	.88 **	.60	.80*	.36	.77*	.63	.25
55%	.47	.93 **	.57	.84 **	.58	.84**	.62	.23
60%	.96**	.95 **	.50	.82*	.36	.83**	.60	.29
70%	.97**	.53	.23	.86 **	.52	.86**	.74*	.47
75%	.96**	.34	.51	.89 **	.64	.88**	.76*	.62
Width of round[d]	.56	.76*	.36	.93 **	.75*	.91**	.65	.50
Width of round (dorsal)[e]	-.16	.84 **	.68	.81*	.54	.96**	.71*	.55
Rib eye area - 12th rib	-.13	.18	.22	.76*	.85**	.86**	.53	.26
Fat thickness (av. 3)	.57	.52	.52	.57	-.11	.87**	-.08	.30
Fat thickness (1)	.55	.01	.33	.32	.02	.77*	-.19	.18
Shank circumference	.25	.26	.83 **	.78*	.73*	.92**	.58	.25

[a]Length measured from the anterior edge of the aitch bone to the highest point on the tarsal bones in the hock joint.

[b]Length measured from anterior edge of first thoracic vertebra to the posterior edge of the last lumbar vertebra.

[c]Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the highest point on the tarsal bones in the hock joint to the anterior edge of the aitch bone.

[d]Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.

[e]Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of aitch bone and just below the fat collar to the outside of the round.

*Significant at 5% level of confidence.

**Significant at 1% level of confidence.

Table 3. Simple correlation coefficients between the percent trimmed four primal cuts and various carcass measurements.

Group Number	I	II	III	IV	V	VI	VII	VIII
Slaughter weight	-.45	-.87**	-.92**	.08	-.18	-.45	-.73*	-.53
Carcass weight	-.52	-.86**	-.87**	.13	-.21	-.46	-.68	-.54
Length hind leg[a]	-.08	-.69	-.85**	.24	-.15	-.37	-.59	-.04
Length vert. column[b]	.07	-.79*	-.61	.45	-.21	-.27	-.66	-.50
Circ. of round[c] - 40%	-.15	-.86**	-.49	-.05	.09	-.07	-.38	-.62
50%	-.20	-.88**	-.54	.05	.21	-.20	-.32	-.49
55%	.22	-.83**	-.60	.06	-.07	-.30	-.12	-.49
60%	-.25	-.88**	-.54	.12	.23	-.19	-.09	-.42
70%	-.40	-.47	-.07	.15	.02	-.27	-.13	-.36
75%	-.34	-.65	-.35	.17	.23	-.47	-.08	-.19
Width of round[d]	-.89**	-.42	-.42	.05	.10	-.35	-.07	-.29
Width of round (dorsal)[e]	-.33	-.68	-.32	-.04	.20	-.45	-.07	-.40
Rib eye area - 12th rib	-.06	-.42	-.06	.67	.20	-.34	.22	-.17
Fat thickness (av. 3)	-.58	-.19	-.70	-.24	.19	-.07	-.44	-.02
Fat thickness (1)	-.76*	-.12	-.42	-.24	-.15	-.11	-.14	-.44
Shank circumference	-.06	-.14	-.71*	-.30	-.12	-.31	.03	.17

[a]Length measured from the anterior edge of the aitch bone to the highest point on the tarsal bones in the hock joint.

[b]Length measured from anterior edge of first thoracic vertebra to the posterior edge of the last lumbar vertebra.

[c]Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the highest point on the tarsal bones in the hock joint to the anterior edge of the aitch bone.

[d]Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.

[e]Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of aitch bone and just below the fat collar to the outside of the round.

*Significant at 5% level of confidence.

**Significant at 1% level of confidence.

Table 4. Simple correlation coefficients between retail yield as predicted by the Brungardt-Bray Round Prediction Formula and various carcass measurements.

Group Number	I	II	III	IV	V	VI	VII	VIII
Slaughter weight	-.47	-.82*	-.85**	.39	-.43	-.78*	-.41	-.59
Carcass weight	-.62	-.77*	-.86**	.42	-.49	-.85**	-.39	-.59
Length hind leg[a]	-.16	-.62	-.77*	.36	-.26	-.59	-.18	-.27
Length vert. column[b]	-.10	-.79*	-.64	.13	-.46	-.69	-.33	-.69
Circ. of round[c] - 40%	-.17	-.71*	-.29	.25	-.18	-.74*	-.09	-.39
50%	-.18	-.78*	-.23	.29	-.12	-.76*	-.13	-.21
55%	.20	-.75*	-.25	.37	-.37	-.79*	.13	-.17
60%	-.34	-.79*	-.20	.36	-.10	-.79*	.10	-.12
70%	-.40	-.47	-.16	.31	-.32	-.79*	.10	-.08
75%	-.40	-.49	-.11	.35	-.11	-.81*	.14	-.01
Width of round[d]	-.72*	-.30	-.35	.48	-.03	-.87**	.08	-.15
Width of round (dorsal)[e]	-.68	-.70	-.26	.39	.20	-.90**	-.11	-.23
Rib eye area - 12th rib	-.16	-.25	-.10	.48	-.26	-.73*	.07	.01
Fat thickness (av. 3)	-.61	-.10	-.82*	-.06	.02	-.83**	-.76*	.12
Fat thickness (1)	-.78*	-.27	-.69	-.02	-.20	-.80*	-.59	-.37
Shank circumference	-.03	-.16	-.74*	.35	-.24	-.95**	.10	.23

[a]Length measured from the anterior edge of the aitch bone to the highest point on the tarsal bones in the hock joint.

[b]Length measured from anterior edge of first thoracic vertebra to the posterior edge of the last lumbar vertebra.

[c]Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the highest point on the tarsal bones in the hock joint to the anterior edge of the aitch bone.

[d]Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.

[e]Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of aitch bone and just below the fat collar to the outside of the round.

*Significant at 5% level of confidence.

**Significant at 1% level of confidence.

Table 5. Simple correlation coefficients between retail yield as predicted by the U.S.D.A. retail yield regression equation and various carcass measurements.

Group Number	I	II	III	IV	V	VI	VII	VIII
Slaughter weight	-.62	-.51	-.47	-.22	-.20	-.66	-.29	-.27
Carcass weight	-.65	-.41	-.40	-.17	-.05	-.72*	-.27	-.14
Length hind leg[a]	-.34	-.54	-.36	.02	.07	-.61	-.27	-.13
Length vert. column[b]	-.22	-.60	-.29	.05	-.39	-.70	-.17	-.11
Circ. of round[c] - 40%	-.35	-.14	.32	-.25	.54	-.37	-.49	.28
50%	-.26	-.15	.31	-.10	.74*	-.41	-.36	.43
55%	-.07	-.19	.24	-.08	.51	-.44	-.17	.38
60%	-.36	-.17	.30	-.05	.60	-.47	-.15	.46
70%	-.56	.30	.58	-.09	.32	-.49	-.06	.31
75%	-.45	.33	.54	-.07	.57	-.44	.01	.46
Width of round[d]	-.84**	-.11	.23	-.18	-.01	-.52	.12	.23
Width of round (dorsal)[e]	-.50	-.58	-.11	-.28	.26	-.72*	.08	.09
Rib eye area - 12th rib	.20	.41	.56	.53	.51	-.72*	.29	.73*
Fat thickness (av. 3)	-.77*	-.51	-.43	-.64	-.46	-.81*	-.57	-.40
Fat thickness (1)	-.81*	-.74*	-.31	-.60	-.73*	-.75*	-.46	-.51
Shank circumference	.01	.08	-.63	-.50	.14	-.77*	.34	.31

[a]Length measured from the anterior edge of the aitch bone to the highest point on the tarsal bones in the hock joint.

[b]Length measured from anterior edge of first thoracic vertebra to the posterior edge of the last lumbar vertebra.

[c]Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the highest point on the tarsal bones in the hock joint to the anterior edge of the aitch bone.

[d]Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.

[e]Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of aitch bone and just below the fat collar to the outside of the round.

*Significant at 5% level of confidence.

**Significant at 1% level of confidence.

This work with the percent four primal cuts is in general agreement with that of Goll et al. (1961b) and Birkett (1963). Goll found low relationships when length of the hind leg, circumference of round, and width of round were correlated with percent four primal cuts. Birkett reported a significant correlation (r = -.52) between carcass weight and the percent four primal cuts, but no other carcass measurements were significantly related to the percent four primal cuts. Orme et al. (1959) reported significant correlations between the percent primal cuts and both width of round and rib eye area. Hedrick et al. (1963) also reported results which were in disagreement with the results reported in this thesis. He found highly significant correlations with length of hind leg, circumference of round, carcass weight, and average fat thickness over the rib eye to the percent primal cuts. In Orme's work the average slaughter weight was 856 pounds with a range of only seventy-six pounds, while Hedrick's study included more variation in weight than that of either Orme or this study.

The Brungardt-Bray round prediction formula (B-B formula) was used as an indicator of retail yield and correlation coefficients were calculated between it and various carcass measurements. The group VI correlation coefficients between this yield indicator and carcass measurements were higher than the other groups. In group VI only the length measurements, length of hind leg and length of vertebral column were not significantly related to the B-B formula. Correlations with the six circumference of round measurements in group VI ranged from (r = -.74) to (r = -.81), while in most other groups these correlations were low and inconsistent with regard to sign. Shank circumference was the most highly related measurement (r = -.95) with the B-B formula (group VI). The B-B formula was developed by using data from three weight groups: namely from groups with left side weights of 260-288 pounds, 300-325 pounds, and 332-360 pounds. Actually the group VIII carcasses in our study, which ranged in carcass weight from 490-594 pounds, came the closest to matching any weight group from which the formula was developed. The group VI carcasses had an average carcass weight of 437 pounds, or a side weight of 219 pounds. Another factor which might have led to the low and nonsignificant relationships is the difference in the genetic variability between the carcasses used to develop the formula and the carcasses to which the formula was applied in our study. Carcasses used in developing the formula were selected at random, within a weight group, from the kill of various days with no knowledge of genetic background. The carcasses used in this study were all sired by one bull which greatly limited the genetic population.

Carcass measurements were not very closely related to the U.S.D.A. regression equation for predicting retail yield. Slaughter weight and carcass weight were not highly related to percentage yield as predicted by the U.S.D.A. equation. Width of round and circumference of round measurements were weakly related to the predicted yield. Fat thickness over the rib eye and rib eye area, both of which are included in the U.S.D.A. equation were not highly related to the yield as predicted by the formula except in isolated cases. In group VI the correlation coefficient between rib eye area and the predicted yield was -.72, while in group VIII the same relationship was .73. Much inconsistency with regard to sign of the correlation coefficients between the carcass measurements and the percentage yield as predicted by the U.S.D.A. regression equation was noted in the data, except in group VIII where a majority were positive.

Carcass measurements do not appear to be strongly related to the percent trimmed four primals, the Brungardt-Bray round prediction formula, and the U.S.D.A. regression equation, as most relationships are low and nonsignificant. No set pattern of increase or decrease in the strength of the relationships between percentage prediction of carcass value and carcass measurements could be associated with increasing length on feed.

Much research work has been done using the physically separable lean, fat and bone of the 9-10-11 rib cut as an endpoint for carcass cutout. In this study the weight of the separable lean from the 9-10-11 rib cut was correlated with various carcass measurements. Figure 5 shows the ninth rib end of the rib cuts of the group I carcasses and figure 6 shows the eleventh rib end of the group VIII rib cuts. Correlation coefficients are presented in Table 6. Slaughter weight was significantly related to 9-10-11 rib lean weight in groups II, III, IV, and V. In groups I through V, carcass weight was significantly correlated with the separable lean weight. This partially agrees with the work of Cole et al. (1960) who found a highly significant correlation (r = .57) between 9-10-11 rib lean weight and carcass weight. The relationship which Cole found occurred on carcasses which weighed 500 pounds. The work here shows decreasing and nonsignificant correlation coefficients in groups VI, VII, and VIII which correspond most closely to carcass weights in Cole's study.

Length of the hind leg and length of the vertebral column were significantly correlated with the separable lean in the 9-10-11 rib cut in groups III and IV. With increasing periods of feed past group IV, the magnitude of the correlation coefficients between the length measurements and the weight of the separable lean of the 9-10-11 rib cut gradually decreased.

The circumference of round measurement relationships followed a familar pattern to that of the length measurements. All six circumference of round measurements were significantly correlated with the 9-10-11 rib

Figure 5. Group I 9-10-11 rib cuts (ninth rib end).

Figure 6. Group VIII 9-10-11 rib cuts (eleventh rib end).

Table 6. Simple correlation coefficients between the weight of the separable lean in 9-10-11 rib cut and various carcass measurements.

Group Number	I	II	III	IV	V	VI	VII	VIII
Slaughter weight	.44	.79*	.80*	.81*	.76*	.67	.51	.22
Carcass weight	.74*	.78*	.83**	.83**	.74*	.69	.61	.41
Length hind leg[a]	.41	.70	.79*	.78*	.64	.47	.32	.45
Length vert. column[b]	.16	.82*	.78*	.92**	.61	.65	.05	.20
Circ. of round[c] - 40%	.54	.65	.80*	.74*	.50	.46	.33	.43
50%	.68	.84**	.72*	.78*	.32	.39	.47	.55
55%	-.13	.83**	.68	.80*	.51	.41	.46	.53
60%	.73*	.82*	.59	.81*	.51	.45	.47	.61
70%	.69	.63	.23	.83**	.71*	.43	.59	.59
75%	.76*	.45	.70	.86**	.61	.43	.66	.71*
Width of round[d]	.20	.41	.49	.78*	.71*	.59	.49	.44
Width of round (dorsal)[e]	.24	.76*	.59	.65	.37	.64	.69	.34
Rib eye area - 12th rib	.46	.42	.29	.92**	.66	.85**	.88**	.76*
Fat thickness (av. 3)	.41	.42	.26	.33	.43	.95**	-.18	-.35
Fat thickness (1)	.66	.35	.01	.10	.50	.95**	.03	-.29
Shank circumference	.18	.40	.69	.44	.29	.78*	.61	.56

[a]Length measured from the anterior edge of the aitch bone to the highest point on the tarsal bones in the hock joint.

[b]Length measured from anterior edge of first thoracic vertebra to the posterior edge of the last lumbar vertebra.

[c]Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the highest point on the tarsal bones in the hock joint to the anterior edge of the aitch bone.

[d]Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.

[e]Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of aitch bone and just below the fat collar to the outside of the round.

*Significant at 5% level of confidence.

**Significant at 1% level of confidence.

lean in group IV. The circumference of round measurements were not strongly related to the separable lean from the 9-10-11 rib cut in other groups.

Rib eye area at the 12th rib was more consistently related to the 9-10-11 rib lean weight than other carcass measurement. The correlation coefficients in groups I, II, and III were not significant, but in subsequent groups the strength of the relationship was increased. The rib eye area in groups IV, VI, VII and VIII was significantly related to the weight of the separable lean in the 9-10-11 rib cut. The significant relationships during the last part of the feeding period are in agreement with Cole et al. (1959) and Cole et al. (1960). In both of the studies by Cole and associates, significant relationships were found between the rib eye area of the twelfth rib and the separable lean of the 9-10-11 rib cut.

Fat thickness measurements were significantly related to the separable 9-10-11 rib lean in only one group. The highly significant correlation ($r = .95$) for both the average of three and the single measurement in group VI was considerably higher than the correlation coefficients of other groups. In group VIII the correlations were negative whereas up to this time an increasing fat thickness was accompanied by an increase in the weight of the separable lean from the 9-10-11 rib cut. In group VI the weight of the lean of the 9-10-11 rib cut and the fat thickness over the twelfth rib were accelerating proportionally at near the same rate. In group VIII either the lean growth had slowed down and the fat had continued accumulating, or the fat accumulation merely accelerated with no like increase in lean growth. The increased accumulation of fat is supported by the data which shows that the primal cuts of carcasses in group VIII had a retail fat trim of 1.98 percent.

Shank circumference was not significantly associated with separable 9-10-11 rib lean except in group VI (r = .78). Lower correlations in other groups indicate that shank circumference is not highly related to 9-10-11 rib lean although there is a positive relationship between the two variables.

Retail Yield of the Beef Round

The weight of the trimmed round (rump on) was correlated with various carcass measurements, muscle areas, and muscle weights. Correlation coefficients between all variables and the trimmed round weight are presented in Table 7. Correlations between the length of the hind leg and the weight of the trimmed round were consistently higher throughout the feeding period than any other variable studied. Length of hind leg was significantly correlated in all groups except group VIII. In this group the correlation (r = .13) was very low. Birkett (1963) and Hedrick et al. (1963) found highly significant relationships between length of the hind leg and weight of the round. Their work does not agree with the low correlation found in group VIII.

Circumference of round measurements showed more variation between groups than between measurements. Generally the correlations of the six round circumference measurements of a group were either all significant or nonsignificant. The relationships between the round circumference measurements and the weight of the trimmed round (rump on) were the weakest in group VIII. In a study involving fat steers of larger size to those in group VIII and with more range in live weight, Birkett (1963) found highly significant relationships between circumference of round measurements and weight of the trimmed round. He found the circumference measurement at

Table 7. Simple correlation coefficients between the weight of the trimmed round (rump on) and carcass measurements, muscle areas, and muscle weights.

Group Number	I	II	III	IV	V	VI	VII	VIII
Length of hind leg[a]	.88**	.97**	.90**	.85**	.82*	.94**	.77*	.13
Circ. of round[b] - 40%	.90**	.81*	.66	.83**	.66	.50	.67	-.11
50%	.86**	.87**	.66	.80*	.25	.61	.75*	.05
55%	.50	.91**	.64	.85**	.42	.71*	.76*	.08
60%	.96**	.93**	.57	.82*	.29	.68	.75*	.14
70%	.998**	.50	.24	.85**	.40	.74*	.86**	.28
75%	.97**	.34	.57	.89**	.59	.80*	.88**	.38
Width of round[c]	.19	.76*	.39	.95**	.85**	.78*	.76*	.23
Width of round (dorsal)[d]	.46	.83**	.69	.84**	.70	.86**	.76*	.20
Area SM[g] - RS[e]	.74*	.85**	.21	.63	.40	.42	.49	.58
SM - 75%[f]	-.00	.52	.65	.52	-.16	.27	.28	.45
BF[h] - RS	-.21	.77*	.67	.91**	.86**	.46	.67	.11
BF - 75%	.42	.88**	-.36	.77*	.38	.29	.35	.15
ST[i] - RS	.78*	.68	.39	.88**	.24	.62	.72*	.76*
ST - 75%	.78*	.80	.57	.83**	-.03	.19	.59	.38
LD[j] - 12th rib	-.18	.19	.24	.72*	.74*	.84**	.56	.17
Muscle wts. SM	.79*	.85**	.80*	.85**	.86**	.66	.70	.68
ST	.93**	.93**	.82*	.88**	.58	.45	.80*	.46
BF	.69	.94**	.70	.82*	.92**	.79*	.74*	.27

[a]Length measured from the anterior edge of the aitch bone to the highest point on the tarsal bones in the hock joint.

[b]Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the hock joint to the anterior edge of the aitch bone.

[c]Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.

[d]Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of the aitch bone and just below the fat collar to the outside of the round.

[e]Muscle surface exposed when rump was removed from round.

[f]Muscle surface exposed by a cut made parallel to the round-rump removal surface and at a point seventy-five percent of the distance from the hock joint to the anterior edge of the aitch bone.

[g]Semimembranosus. [h]Biceps femoris. [i]Semitendinosus. [j]Longissimus dorsi.

*Significant at 5% level of confidence. **Significant at 1% level of confidence.

forty percent of the distance from the hock to the aitch bone to be the most highly related to the trimmed round weight.

Apparently the accuracy of circumference of round in predicting trimmed round weight varies depending on the stage of growth and length of feeding. During much of the fattening period the accuracy is quite high, but during other parts the measurement is not accurate. This may be due to several reasons. First, a weak relationship may exist and we are accurately measuring the relationships as they change during the fattening. Secondly, even though these calves were by one sire and were randomly divided into lots or groups, there may be a definite group difference in shape and size of round. This could lead to possible group variation in the significance of the round circumference measurements. Another limitation may be the fact that we have only eight steers per group.

The width of round and width of round (dorsal) were highly related to trimmed round weight in groups II, IV, V, VI and VII. Little difference appears to exist between the two measurements in terms of the significance of their correlation coefficients among groups. This is in partial disagreement with work reported by Goll et al. (1961b). He stated that the width of round was more highly related to yield of round than either length of hind leg or circumference of round. Although significant correlation coefficients were found in some groups, group VIII, a group which would most nearly have the same weight range as Goll's carcasses, showed no significant relationships between round width and trimmed round weight. Also, in the study reported in this thesis, the length of hind leg was more highly related to trimmed round yield than the width measurements.

Most of the carcass measurements of the round appear to have some value in estimating the weight of the trimmed round. It is important to note that correlation coefficients for all measurements in group VIII were considerably lower and nonsignificant in comparison to other groups. The main difference between group eight and the other groups is fat accumulation on the round. The round measurements were made before any fat trimming was made, while the correlations are with the trimmed round weight.

Correlation coefficients between muscle area measurements and the weight of the trimmed round were generally nonsignificant, but some trends developed in the coefficients. The correlations between the round removal surface individual muscle areas and the round weight were generally higher and tended to be more significant than those between the seventy-five percent surface individual muscle areas and the round weight. This may be due to the probable increased accuracy in separating the round and the rump. This surface was approximately at the same location on each carcass, whereas the position of the seventy-five percent cut varied with the length of the hind leg of the carcass.

Correlation coefficients between the rib eye area at the twelfth rib and the weight of the trimmed round were .72, .74 and .84 for groups IV, V and VI, respectively. The correlations for other groups were low and nonsignificant. Birkett (1963) found a highly significant correlation between rib eye area and weight of the trimmed round, but his cattle would only compare to group VIII, which in this study gave a low and nonsignificant correlation ($r = .17$) between rib eye area and weight of the trimmed round.

Round muscle weights were more highly related to the trimmed round weight than the areas of these same muscles. This stands to reason due to the fact that the muscle weights, individually, make up part of the whole. The correlation coefficients of no one group appeared to be much lower than any other group. Most correlations were significant. No single round muscle weight appeared to be more accurate than any other in predicting the trimmed round weight.

Correlation coefficients were determined between the retail cuts of the beef round and various carcass measurements and muscle areas. The round, after the rump had been removed, was divided into the bottom round, top round, sirloin tip and heel of round. All retail cuts were completely boned.

No specific carcass measurement or muscle area was outstanding in the prediction of the bottom round weight throughout the feeding period. Correlation coefficients of bottom round weight with carcass measurements and muscle areas appear in Table 8. Correlations between length of hind leg and weight of bottom round improved with length of feeding to a significant level in groups V and VI, but were not significant in cattle fed for 196 and 224 days. Relationships between circumference of round measurements and the bottom round weight were generally low and nonsignificant in the first parts of the feeding period. In groups VI and VII, the circumference of round was significantly related to the bottom round weight. Correlation coefficients between the width of round measurements and bottom round weight followed a similar pattern to the correlations for the circumference measurements. Relationships were weak in the first four feeding period groups and improved to significance in groups V, VI and VII.

Muscle areas of the round and rib eye were correlated with the bottom round weight. The area of the semimembranosus (SM) was not significantly related to the bottom round weight in any group. This is reasonable as the SM is not included in the bottom round weight. The area of the biceps femoris (BF) at the round removal surface was significantly correlated with the bottom round weight in group V ($r = .80$) and in group VII ($r = .90$).

Table 8. Simple correlation coefficients between the weight of the bottom round and carcass measurements, muscle areas, and muscle weights.

Group Number	I	II	III	IV	V	VI	VII	VIII
Length of hind leg[a]	.21	.40	.35	.60	.73*	.74*	.69	.41
Circ. of round[b] - 40%	.36	.05	.01	.31	.22	.61	.54	.29
50%	.48	.25	-.14	.31	-.10	.79*	.60	.32
55%	-.44	.29	-.10	.35	.15	.85**	.74*	.36
60%	.45	.24	-.17	.37	-.03	.79*	.76*	.37
70%	.38	.18	-.50	.51	.28	.86**	.83**	.56
75%	.51	-.00	-.41	.51	.33	.88**	.89**	.52
Width of round[c]	.23	.09	-.08	.56	.79*	.76*	.66	.32
Width of round (dorsal)[d]	.29	.45	.08	.53	.74*	.81*	.75*	.53
Area SM[g] - RS[e]	-.26	.14	.29	.63	.18	.28	.30	.49
SM - 75%[f]	.37	.71*	-.11	.70	-.34	.38	.52	.22
BF[h] - RS	.05	.51	-.13	.53	.80*	.64	.90**	.36
BF - 75%	.22	.31	.25	.93**	.39	.43	.71*	-.17
ST[i] - RS	.15	.12	.28	.70	.14	.77*	.70	.31
ST - 75%	.49	.34	-.08	.54	.22	.61	.86**	.22
LD[j] - 12th rib	.44	.14	-.49	.61	.45	.41	.64	.11
Muscle wts. SM	.33	.75*	.58	.85**	.55	.58	.87**	.65
ST	.35	.45	.66	.65	.45	.72*	.88**	.60
BF	.18	.49	.27	.85**	.74*	.70	.90**	.62

[a] Length measured from the anterior edge of the aitch bone to the highest point on the tarsal bones in the hock joint.

[b] Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the hock joint to the anterior edge of the aitch bone.

[c] Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.

[d] Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of the aitch bone and just below the fat collar to the outside of the round.

[e] Muscle surface exposed when rump was removed from round.

[f] Muscle surface exposed by a cut made parallel to the round-rump removal surface and at a point seventy-five percent of the distance from the hock joint to the anterior edge of the aitch bone.

[g] Semimembranosus. [h] Biceps femoris. [i] Semitendinosus. [j] Longissimus dorsi.

*Significant at 5% level of confidence. **Significant at 1% level of confidence.

At the seventy-five percent surface the BF was significantly correlated with the bottom round weight in group IV (r = .93) and in group VII (r = .71). The bottom round weight was significantly correlated with the area of the semitendinosus (ST) at the round removal surface in group VI (r = .77) and at the seventy-five percent surface in group VII (r = .86). Other correlation coefficients between round muscle areas and the bottom round weight were nonsignificant. The rib eye area at the twelfth rib was not significantly correlated with the bottom round weight in any group.

The results dealing with the prediction of the bottom round weight show that no measurement or muscle area studied could be used throughout the feeding period to predict the bottom round weight although an apparent trend was noted for the carcass measurements of round width, round circumference and length of hind leg. During the early stages of feeding and growth, their relationship with bottom round weight was low, while in later periods the relationships improved. Significant relationships between muscle areas and the bottom round weight were scattered, and no trends or patterns seemed evident. In terms of groups, the relationships with the bottom round weight were consistently the highest in groups VI and VII. Correlation coefficients were varied and generally lower in other groups.

The weight of the top round was correlated with various carcass measurements and muscle areas. Correlation coefficients involving the weight of the top round are presented in Table 9. All correlations in group I were nonsignificant. Correlations between the top round weight and the muscle areas were lower than those between the top round weight and the carcass measurements. In groups II and III, length of hind leg was significantly related to top round weight (r = .77 and .75), respectively. Circumference of round and width of round measurements were not significantly

Table 9. Simple correlation coefficients between the weight of the top round and carcass measurements, muscle areas and muscle weights.

Group Number	I	II	III	IV	V	VI	VII	VIII
Length of hind leg[a]	.22	.77*	.75*	.68	.73*	.43	.61	.56
Circ. of round[b] - 40%	.63	.35	.29	.75*	.69	.30	.52	.65
50%	.61	.48	.14	.73*	.40	.36	.59	.69
55%	.14	.58	.11	.77*	.46	.44	.72*	.64
60%	.68	.61	.04	.78*	.42	.35	.71*	.69
70%	.63	.29	.11	.83**	.44	.41	.71*	.79*
75%	.56	.18	.10	.86**	.68	.53	.79*	.91**
Width of round[c]	.61	.47	.37	.93**	.74*	.49	.49	.67
Width of round (dorsal)[d]	.54	.69	.34	.85**	.67	.52	.76*	.76*
Area SM[g] - RS[e]	.16	.49	-.05	.65	.41	.09	.34	.86**
SM - 75%[f]	.21	.54	.32	.68	.01	.87**	.19	.37
BF[h] - RS	.03	.69	.45	.81*	.79*	.42	.86**	-.04
BF - 75%	.04	.69	-.02	.79*	.30	.53	.86**	.55
ST[i] - RS	.35	.58	.12	.81*	.22	.46	.58	.68
ST - 75%	.63	.78*	.41	.82*	.01	.60	.85**	.60
LD[j] - 12th rib	.32	.09	.11	.66	.78*	.58	.74*	.61
Muscle wts. SM	.29	.86**	.83**	.92**	.87**	.91**	.81*	.79*
ST	.52	.79*	.66	.86**	.50	.74*	.76*	.85**
BF	.30	.85**	.41	.87**	.82*	.69	.80*	.50

[a]Length measured from the anterior edge of the aitch bone to the highest point on the tarsal bones in the hock joint.

[b]Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the hock joint to the anterior edge of the aitch bone.

[c]Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.

[d]Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of the aitch bone and just below the fat collar to the outside of the round.

[e]Muscle surface exposed when rump was removed from round.

[f]Muscle surface exposed by a cut made parallel to the round-rump removal surface and at a point seventy-five percent of the distance from the hock joint to the anterior edge of the aitch bone.

[g]Semimembranosus. [h]Biceps femoris. [i]Semitendinosus. [j]Longissimus dorsi.

*Significant at 5% level of confidence. **Significant at 1% level of confidence.

related to the top round weight in the second and third groups. In these same two groups, all correlation coefficients between muscle areas and the top round weight were nonsignificant, except the ST area at the seventy-five percent surface in group II, which was significantly correlated with the weight of the top round (r = .78).

Circumference of round measurements were significantly and highly significantly related to the weight of the top round in group IV. The strength of the relationship improved from the fifty down to the seventy-five percent measurement (r = .73 at fifty percent of the distance from the hock to the aitch bone and r = .86 at the seventy-five percent distance). This may be explained by the fact that the SM, the largest muscle of the top round, is increasing in size (volume) from the fifty percent measurement to the seventy-five percent distance. Width of round measurements were highly significantly related to the weight of the top round (r = .93 for width of round and r = .85 for width of round-dorsal). The areas of the SM and the longissimus dorsi (LD) were not significantly related to the weight of the top round while the areas of the BF and ST were highly significantly related.

The relationships of the top round weight to carcass measurements and muscle areas in groups V and VI were generally lower. The top round weight was significantly correlated with length of the hind leg (r = .73) and the area of the rib eye (r = .78) in group V and was highly significantly correlated with the area of the SM at the seventy-five percent surface (r = .87) in group VI.

The relationships in the last two groups improved for some carcass measurements and muscle areas. Circumference of round measurements seemed to be more accurate in the prediction of the top round weight in groups VII and VIII than they had been in groups V and VI. Width of round (dorsal) was significantly correlated with the weight of the top round in both group VII and group VIII (r = .76 for both groups). The area of the SM at the round removal surface was highly significantly correlated with the top round weight in group VIII (r = .86). In group VII the areas of the BF, ST, and LD were significantly related to the weight of the top round.

The situation which prevailed in the prediction of the bottom round weight seems to be present in the prediction of the top round weight. No carcass measurement or muscle area is consistently related to the top round weight throughout the feeding period. Individual correlations are high and various groups of correlations are high, but no pattern is developed and carried through the feeding period for the prediction of the top round weight.

The weight of the sirloin tip or knuckle, another retail cut of the beef round, was correlated with muscle areas and carcass measurements. Correlation coefficients are given in Table 10. The muscle areas of the round were not highly related to the sirloin tip weight. This may be partly due to the anatomical positions of sirloin tip and the muscles from which the areas were traced (SM, ST, and BF). The sirloin tip is not made up of any of these three muscles. Muscle areas and muscle weights were not obtained for the individual muscles within the sirloin tip. The relationships between the rib eye area at the twelfth rib and the weight of the sirloin tip were low and nonsignificant.

Length of hind leg was significantly related to the sirloin tip weight in groups I (r = .93), IV (r = .75), and V (r = .76). Circumference of round measurements were significantly correlated with the sirloin tip weight in group I, but the correlation coefficients of other groups were not

Table 10. Simple correlation coefficients between the weight of the sirloin tip and carcass measurements, muscle areas, and muscle weights.

Group Number	I	II	III	IV	V	VI	VII	VIII
Length of hind leg[a]	.93**	.60	.07	.75*	.76*	.62	.68	.06
Circ. of round[b] - 40%	.84**	.79*	.66	.58	.63	.10	.45	.45
50%	.80*	.69	.73*	.51	.19	.24	.36	.50
55%	.50	.64	.65	.55	.46	.30	.35	.44
60%	.92**	.62	.68	.52	.17	.28	.25	.41
70%	.97**	.35	.26	.59	.32	.34	.38	.46
75%	.96**	.33	.49	.65	.40	.32	.37	.53
Width of round[c]	.05	.46	-.29	.71*	.58	.26	.30	.23
Width of round (dorsal)[d]	.44	.34	.24	.50	.32	.37	.07	.36
Area SM[g] - RS[e]	.76*	.48	.22	.31	.28	-.14	-.06	.12
SM - 75%[f]	.00	.35	.26	.26	-.03	.09	.02	.42
BF[h] - RS	-.25	.46	.27	.69	.68	.23	.04	.24
BF - 75%	.46	.51	-.79*	.82*	.48	.30	-.29	.04
ST[i] - RS	.81*	.12	.33	.62	.31	.23	.10	-.01
ST - 75%	.78*	.27	.39	.64	-.09	.01	-.13	.23
LD[j] - 12th rib	-.21	.13	.00	.69	.60	.38	-.07	.31
Muscle wts. SM	.86**	.38	.08	.65	.76*	.45	-.02	.43
ST	.92**	.47	.35	.64	.73*	.12	.17	.32
BF	.69	.40	.72*	.73*	.85**	.37	.06	.56

[a]Length measured from the anterior edge of the aitch bone to the highest point on the tarsal bones in the hock joint.

[b]Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the hock joint to the anterior edge of the aitch bone.

[c]Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.

[d]Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of the aitch bone and just below the fat collar to the outside of the round.

[e]Muscle surface exposed when rump was removed from round.

[f]Muscle surface exposed by a cut made parallel to the round-rump removal surface and at a point seventy-five percent of the distance from the hock joint to the anterior edge of the aitch bone.

[g]Semimembranosus. [h]Biceps femoris. [i]Semitendinosus. [j]Longissimus dorsi.

*Significant at 5% level of confidence. **Significant at 1% level of confidence.

statistically significant. Width of round measurements were not accurate in predicting the weight of the sirloin tip.

It appears that none of the variables studied in relation to the weight of the sirloin tip were accurate in the prediction of the sirloin tip. Some measurement which might be more nearly associated with sirloin tip section of the round might prove to be more valuable. Certainly, muscle areas of muscles in another section of the round were not the answer. The measurements which were made on the round also proved to be of little value.

Circumference of round measurements appear to be of value in predicting the heel of round weight. The greater the circumference of the round, the larger the weight of the heel of round. The circumference of round measurements nearest the hock joint were the most highly related to the weight of the heel of round. The circumference of round at a distance of forty percent of the length of the hind leg measured from the hock end of the round was significantly correlated with the heel of round weight in groups I, II, IV, V and VII. Correlation coefficients for these measurements and other variables with the weight of the heel of round are presented in Table 11.

Length of the hind leg was highly significantly correlated with the weight of the heel of round in group IV ($r = .89$), but no significant relationship was found in any other group for this variable. The heel of round weight was significantly related to width of round in group IV ($r = .85$) and in group VIII ($r = .79$) and to width of round (dorsal) in group IV ($r = .72$).

Area measurements of the round muscles were weakly related to the heel of round weight in the first parts of the feeding period, but in group IV and especially in group VIII, the relationships were quite high. In group VIII the heel of round was significantly related to both areas of the SM

Table 11. Simple correlation coefficients between the weight of the heel of round and carcass measurements, muscle areas, and muscle weights.

Group Number	I	II	III	IV	V	VI	VII	VIII
Length of hind leg[a]	.55	.52	.56	.89**	.44	.39	.41	.24
Circ. of round[b] - 40%	.89**	.76*	.48	.79*	.84**	.55	.87**	.67
50%	.86**	.67	.51	.74*	.84**	.48	.92**	.69
55%	.24	.58	.63	.79*	.88**	.51	.92**	.66
60%	.83**	.61	.57	.74*	.74*	.50	.88**	.60
70%	.72*	.16	-.04	.76*	.63	.49	.81*	.67
75%	.73*	.33	.25	.80*	.69	.52	.78*	.73*
Width of round[c]	.14	.37	.42	.85**	.19	.64	.62	.79*
Width of round (dorsal)[d]	.40	.48	.45	.72*	.14	.61	.70	.67
Area SM[g] - RS[e]	.29	.43	.42	.55	.62	.56	.31	.72*
SM - 75%[f]	.21	.25	.49	.31	.34	.35	-.23	.83**
BF[h] - RS	.23	.15	.12	.86**	.37	.36	.62	.08
BF - 75%	.56	.63	-.17	.65	.59	.48	.37	.85**
ST[i] - RS	.31	.40	.20	.82*	.75*	.32	.35	.79*
ST - 75%	.49	.42	.05	.71*	.33	.25	.38	.96**
LD[j] - 12th rib	.11	.13	.04	.63	.71*	.78*	.52	.51
Muscle wts. SM	.43	.35	.55	.69	.58	.62	.48	.74*
ST	.54	.57	.66	.75*	.56	.46	.46	.79*
BF	.34	.41	.33	.68	.39	.63	.46	.63

[a]Length measured from the anterior edge of the aitch bone to the highest point on the tarsal bones in the hock joint.

[b]Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the hock joint to the anterior edge of the aitch bone.

[c]Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.

[d]Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of the aitch bone and just below the fat collar to the outside of the round.

[e]Muscle surface exposed when rump was removed from round.

[f]Muscle surface exposed by a cut made parallel to the round-rump removal surface and at a point seventy-five percent of the distance from the hock joint to the anterior edge of the aitch bone.

[g]Semimembranosus. [h]Biceps femoris. [i]Semitendinosus. [j]Longissimus dorsi.

*Significant at 5% level of confidence. **Significant at 1% level of confidence.

and ST and significantly related to the area of the BF at the seventy-five percent surface. The area of the LD at the twelfth rib was significantly related to the heel of round weight in groups V and VI.

The heel of round weight appears to be more easily predicted from the variables examined in this study than any of the other retail cuts of the round that were studied. Circumference of round measurements near the hock end of the round were consistently significantly related to the heel of round weight. It is logical that these measurements might be highly related to the heel weight because they actually measured the distance around this retail cut. The heel of the round is the least desirable retail cut of the round from the standpoint of market value and consumer quality, but it appears to be the only cut which can be accurately measured by the variables used in this study.

An analysis of the relationships of the retail yield of various sections of the beef round to the carcass measurements and muscle areas points up the fact that correlation coefficients of the fourth feeding period group were consistently higher than other groups. This was the case not only in the prediction of the trimmed round (rump on), but also in the case of the four retail cuts of the round. It is of interest to examine characteristics of this group which might lead to a knowledge of the higher correlations.

The average carcass weight of the group IV was 334 pounds. The range in carcass weight was 258-410 pounds. The range in live weight was 425-630 pounds. The carcasses were classified as beef with one carcass grading U.S.D.A. Choice and seven grading U.S.D.A. Good. The average of three fat thickness measurements over the rib eye ranged from .28 inch to .52 inch with the average of the eight carcasses being .38 inch. From this data it is evident that the round retail yield relationships were the most useful on carcasses which were not extremely fat.

Muscle Development

Muscle development of the semimembranosus (SM), semitendinosus (ST), biceps femoris (BF), and longissimus dorsi (LD) was studied in the eight feeding groups. Development was measured by the cross-sectional area of the muscle surfaces and by the weights of the dissected muscles. Relationships of the muscle weights to muscle areas and carcass measurements were also determined. The weight of the LD is the total weight of the muscle except for that appearing in the 6-7-8 rib section which was used in a cooking study involving the 6-7-8 rib roast and therefore was not dissected out. Average muscle weights are given in Table 12 and average muscle areas are presented in Table 13. Weight and area measurements of the round muscles and the LD are graphically shown in figure 7 and 8.

The SM and BF were the largest of the three round muscles studied in the weanling calves (group I). The SM weighed 3.15 pounds compared to 1.40 pounds for the ST, and 2.85 pounds for the BF. The SM weight increased .80 pound between groups I and II and .65 pound from group II to group III. There was no increase in the SM weight between groups III and IV. The biggest increase in weight was between groups V and VI, where an increase of .86 pound was over three times as great as the increase of .25 pound between groups VI and VII. The average weight of the SM in group VII of 6.20 pounds was the most the muscle weighed as the weight of the SM was 5.94 pounds in group VIII.

The weight of the ST was the smallest of the round muscle weights all through the feeding period. The ST gradually increased in weight through

Table 12. Average muscle weights in pounds.

Group Number	I	II	III	IV	V	VI	VII	VIII
Semitendinosus	1.40	1.88	2.20	2.36	2.53	2.86	2.93	2.99
Semimembranosus	3.15	3.95	4.60	4.61	5.09	5.95	6.20	5.94
Biceps femoris	2.85	3.83	4.35	4.26	4.41	5.03	5.53	5.50
Longissimus dorsi	3.03	4.06	4.95	4.52	5.41	5.98	6.44	6.86

Table 13. Average muscle areas in square inches.

Group Number	I	II	III	IV	V	VI	VII	VIII
Semimembranosus - RS[a]	8.98	10.55	11.30	11.60	13.20	14.46	15.58	17.22
Semimembranosus - 75%[b]	13.77	13.53	16.90	18.09	19.70	21.86	23.30	21.59
Biceps femoris - RS	8.84	10.20	12.32	12.25	12.84	14.32	14.77	15.52
Biceps femoris - 75%	5.86	8.58	8.65	8.30	9.29	9.68	11.36	10.23
Semitendinosus - RS	3.68	4.93	5.55	5.62	6.98	7.45	7.82	8.96
Semitendinosus - 75%	3.89	4.74	5.61	6.09	6.70	7.46	7.60	8.37
Longissimus dorsi - 12th rib	5.44	5.97	7.87	7.68	8.33	8.84	9.31	10.16

[a]Muscle surface exposed when rump was removed from round.

[b]Muscle surface exposed by a cut made parallel to the round-rump removal surface and at a point seventy-five percent of the distance from the hock joint to the anterior edge of the aitch bone.

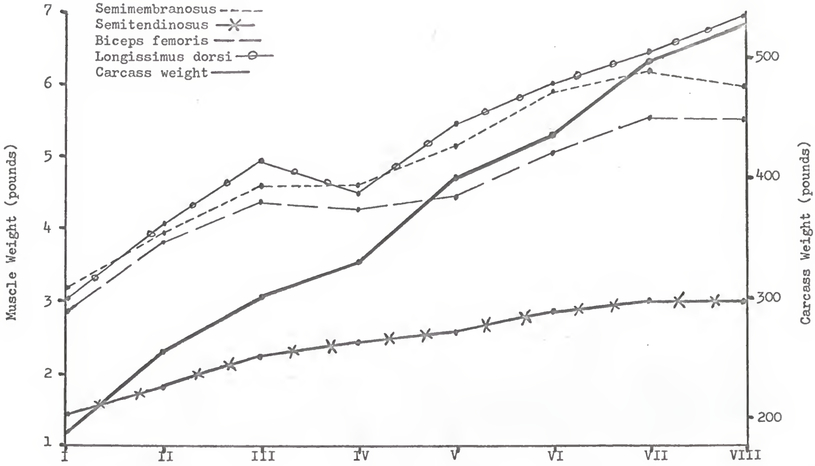

Figure 7. Muscle weight and carcass weight (group averages).

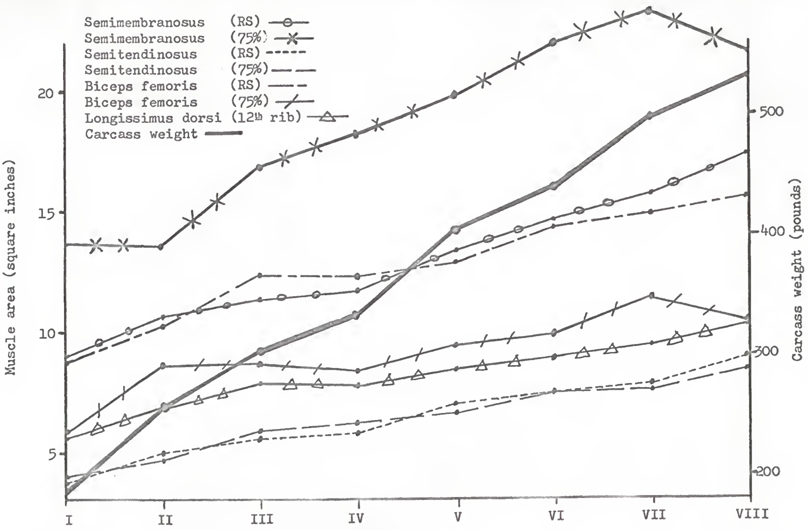

Figure 8. Muscle areas and carcass weight (group averages).

the feeding period, tapering off somewhat in the last two groups. The ST weighed 1.40 pounds in the group I carcasses and 1.88 pounds in the group II carcasses. The difference of .48 pound might seem large in comparison to differences of .32, .16, .17 and .33 pound between the following groups, but the steers were on feed fifty-six days between the first two groups, while there was only a twenty-eight day feeding period between the remainder of the groups. The ST weighed 2.99 pounds in group VIII which was about one half of the SM weight in the same group. This weight in group VIII is similar to the weight of the ST reported by Orme et al. (1960). Using forty-three mature Hereford cows weighing from 825 pounds to 1410 pounds, he reported a weight of 3.72 pounds for the ST.

The BF followed a weight development pattern similar to the SM. Weighing 2.85 pounds in group I, the average weight of the BF increased to 3.83 pounds in group II and increased to 4.35 pounds in group III. Between group III and group IV the average weight decreased about one tenth of a pound. The muscle increased in weight from group IV until it reached its peak in groups VII and VIII weighing 5.53 and 5.50 pounds. This is the same basic pattern of weight development that was found with the SM. The SM weight showed little increase between groups III and IV and reached its peak in group VII.

Orme et al. (1960) found an average weight of 10.49 pounds for the BF in mature Hereford cows. This is considerably larger than the weights reported in this thesis. The difference could be due to many reasons. First, the muscle may be further developed in terms of weight in the eight and one-half to eleven year old cows than the yearling steers. Secondly, there may be a breed difference between the Herefords and the Angus used in this study. Another possible difference is the definition of the BF.

This study did not include the BF (ischiotic head) while the study by Orme may have included this in the BF muscle weight.

The LD, minus the 6-7-8 rib section, weighed 3.03 pounds in group I and increased in weight to 6.86 pounds in group VIII. This muscle also decreased in weight between groups III and IV, possibly reflecting differences in cattle used in these 2 groups. The LD showed a larger increase in weight between groups VII and VIII than the round muscles. Orme et al. (1960) reported a much larger LD in mature Hereford cows (10.97 pounds). The ST and LD showed the greatest percentage increase in weight of the four muscles studied. They doubled their weight from weaning to 224 days on feed, while the SM and BF failed to do this. The SM, BF, and LD comprised the largest total weight while the ST was the lightest muscle studied.

The area development of the round muscles was measured at the round removal surface (RS) and at the point which was seventy-five percent of distance from the hock joint to the anterior point of the aitch bone (75%). The area of the SM at the RS followed a pattern of gradual increase during the feeding period. As was the case with the weight of the SM, a smaller increase in the area was observed between groups III and IV. There was a substantial increase between groups VII and VIII in the area of the SM at the RS which does not correspond to the reduction in the SM weight during the last feeding period. The area of the SM (75%) also followed a pattern of increase through the feeding period, except in the last feeding period. The decrease in area from group VII to group VIII was as great as the increase from group VI to group VII. A relationship may exist between the SM weight and the SM (75%) area as they both decreased in the last feeding period. The SM was larger at the 75% surface than the RS in each group.

The BF (RS) increased in area through the feeding period except between groups III and IV where the area decreased slightly. The area of 8.84 square inches in group I increased to 15.52 square inches in group VIII. The area of BF (75%) between groups III and IV also decreased. This area decrease is in agreement with the BF weight developmental picture. The weight decreased from group III to group IV. The BF (75%) reached its peak in area in group VII (11.36 square inches), and like the SM (75%), decreased in area in group VIII.

The ST, at both the RS and 75%, followed a trend of gradual increase in area through the feeding period. Although the smallest muscle in terms of area, the ST showed the greatest percentage increase in area from the beginning of the feeding period to the end of the feeding period. The ST (RS) showed an increase of 1.36 square inches between group IV and group V. The ST (75%) area showed a substantial increase between groups VII and VIII. This was in reverse of the situation found with the areas to the 75% surface in the other round muscles.

The area of the SM at the 75% surface was the largest average area recorded among the round muscle areas. The SM showed the largest area at the 75% surface and a smaller area at the round removal surface, while the area of the BF was larger at the RS and smaller at 75%. This may be explained by the muscle position in the round (rump on) with respect to where the areas were traced. The BF carried much further into the rump section and its thickest, largest portion was more closely aligned with the RS measurement. The SM, in contrast, was found mainly in the round section of the round (rump on), and its thickest mass occurred nearest the 75% tracing. The ST showed little difference in the size of the area at the RS and 75% surfaces. This points up the fact that the ST is more or less uniform in its cross sectional area through the round.

The area of the LD at the twelfth rib gradually increased throughout the feeding and growth period. In group I the average area was 5.44 square inches and increased to 5.97 square inches in group II. Between groups II and III an average increase of 1.90 square inches was observed, but between groups III and IV the area decreased. The area showed another substantial increase (1.65 square inches) between groups IV and V, and then gradually increased through the rest of the feeding period.

The situation where no increase in muscle area from one group to another might be explained by saying that actually no development in muscle area occurred during the period. When a decrease is noted in muscle area from one group to the next, something may be wrong with the sample. Either the first group of the pair was superior to the normal developmental pattern, or the second group of the pair was inferior to the population standard. The biggest gross factors which can be used to see how well the group fit the population are slaughter weight and carcass weight. The group IV steers and carcasses had a larger weight range than those in group III. The average carcass weights reveal that the periods on either side of group III-IV (from group II to group III and from group IV to group V) had a larger gain in average carcass weight than the period between groups III and IV showed. The average carcass weight only increased thirty-two pounds from group III to group IV, while the average carcass weight increased forty-four pounds between groups II and III and sixty-seven pounds between groups IV and V. This difference alone could account for some of the decreases in measurements from group III to group IV.

The weight of the SM from the round (rump on) was correlated with various muscle areas and carcass measurements. Correlation coefficients between the SM weight and the area of the SM at RS were highly significant in group IV (r = .83) and in group VIII (r = .85). The area of the SM at 75% was significantly correlated with the SM weight in groups II (r = .81), IV (r = .87) and VIII (r = .75). Relationships between the SM weight and other muscle areas were generally statistically significant in group IV, while other groups appeared more variable. Correlation coefficients between the SM weight and all variables are presented in Table 14.

The circumference of the round measurements were more highly correlated to the weight of the SM when the circumference measurement was taken around the thicker part of the round in comparison to circumference measurements closer to the hock joint. The width of round (dorsal) was significantly related to the SM weight in more groups than the width of round measurement. This may be due to the fact that the width of round (dorsal) measurement was made through the thickest part of the round, this being the section in which the largest mass of SM is located. The weight of the trimmed round was highly related to the SM weight. The correlation reached its peak in group V (r = .86) but was lower in the last three feeding periods. Length of the hind leg was significantly related to the SM weight in group I (r = .74) and highly significantly related to the SM weight in groups II (r = .85) and V (r = .93). Length of the vertebral column (anterior edge of first thoracic to posterior edge of last lumbar) was highly related (r = .91) to the SM weight in group II, but the correlation coefficients were negative and low in the last of the feeding period. The vertebral column length times the rib eye area at the twelfth rib was significantly correlated (r = .94 and r = .86) with the SM weight in groups V and VII, respectively. The addition of the length measurement to

Table 14. Simple correlation coefficients between the weight of the semimembranosus and muscle areas and carcass measurements.

Group Number	I	II	III	IV	V	VI	VII	VIII
Area SM[c] - RS[a]	.59	.63	.44	.83**	.40	.26	.60	.85**
SM - 75%[b]	.40	.81*	.59	.87**	.18	.70	.56	.75*
BF[d] - RS	-.22	.71*	.69	.70	.87**	.49	.88**	.20
BF - 75%	.35	.74*	-.00	.83**	.49	.50	.76*	.45
ST[e] - RS	.53	.53	.48	.87**	.48	.63	.88**	.86**
ST - 75%	.78*	.72*	.43	.82*	.29	.57	.96**	.77*
LD[f] - 12th rib	.00	.21	.29	.63	.89**	.51	.81*	.33
Circ. of round[g] - 40%	.59	.63	.59	.67	.73*	.38	.42	.48
50%	.74*	.78*	.37	.67	.49	.42	.57	.53
55%	.28	.81*	.34	.70	.69	.48	.65	.53
60%	.82*	.79*	.26	.74*	.55	.41	.73*	.51
70%	.80*	.48	.17	.83**	.68	.46	.78*	.71*
75%	.87**	.26	.39	.83**	.80*	.54	.84**	.78*
Width of round[h]	-.18	.49	.47	.86**	.65	.51	.69	.72*
Width of round (dorsal)[i]	.10	.82*	.69	.87**	.57	.44	.87**	.75*
Wt. trimmed round	.79*	.85**	.80*	.85**	.86**	.66	.70	.68
Length of hind leg[j]	.74*	.85**	.58	.57	.93**	.45	.41	.40
Length of vert. column[k]	.66	.91**	.57	.67	.57	.43	-.13	-.27
(Vert. column length) x (LD area - 12th rib)[l]	.24	.67	.52	.64	.94**	.52	.86**	.45

[a]Muscle surface exposed when rump was removed from round.
[b]Muscle surface exposed by a cut made parallel to the round-rump removal surface and at a point seventy-five percent of the distance from the hock joint to the anterior edge of the aitch bone.
[c]Semimembranosus. [d]Biceps femoris. [e]Semitendinosus. [f]Longissimus dorsi.
[g]Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the hock joint to the anterior edge of the aitch bone.
[h]Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.
[i]Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of the aitch bone and just below the fat collar to the outside of the round.
[j]Length measured from the anterior edge of aitch bone to the highest point on the tarsal bones in the hock joint.
[k]Length measured from anterior edge of first thoracic vertebra to posterior edge of last lumbar vertebra.
[l]Product of the vertebral column length and the area of the longissimus dorsi at the twelfth rib.
*Significant at the 5% level of confidence. **Significant at the 1% level of confidence.

the area measurement of the twelfth rib improved the correlation over the area measurement alone in the estimation of the SM weight.

Correlation coefficients between the weight of the ST and various muscle areas and carcass measurements are presented in Table 15. Areas of the ST at RS and 75% were highly related to the ST weight in most groups. The areas of the SM, BF, and LD were not as highly related to the ST weight as the ST areas were. The area of the LD at the twelfth rib was significantly related to the ST weight in groups IV (r = .83) and V (r = .76). In all other groups the weight of the ST was weakly related to the LD area. Orme (1958) also found that the weight of the ST was not highly correlated with the rib eye area. Orme et al. (1959) reported that the rib eye area was significantly related to the percent of ST (r = .40). This work was done on thirty-one Angus and Hereford steers which had an average live slaughter weight of 856 pounds.

The weight of the ST, like the weight of the SM, was more highly related to the circumference of round measurement at 75% distance than any other round circumference measurement. Only in groups II, III and V was the circumference of round at the 75% distance not significantly related to the weight of the ST. Width of round and width of round (dorsal) were significantly correlated with the ST weight in various groups. Generally the relationships between these two width measurements and the ST weight were higher at the end of the feeding period. Weight of the trimmed round was highly correlated with the ST weight in the first half of the feeding period, while correlations in the last half of the feeding period were lower. Length of hind leg and length of the vertebral column were both significantly related to the ST weight in groups I, II, IV and V. This points up the fact that the length variables may be more important in

Table 15. Simple correlation coefficients between the weight of the semitendinosus and muscle areas and carcass measurements.

Group Number	I	II	III	IV	V	VI	VII	VIII
Area SM[c] - RS[a]	.69	.68	.54	.69	.17	.40	.58	.92**
SM - 75%[b]	-.07	.49	.54	.64	.35	.71*	.55	.65
BF[d] - RS	-.53	.61	.52	.85**	.78*	.77*	.82*	.10
BF - 75%	.15	.95**	-.18	.74*	.54	.64	.61	.60
ST[e] - RS	.79*	.75*	.65	.97**	.52	.74*	.87**	.85**
ST - 75%	.84**	.82	.52	.98**	.44	.96**	.87**	.83**
LD[f] - 12th rib	-.36	.06	-.12	.83**	.76*	.28	.64	.35
Circ. of round[g] - 40%	.71*	.63	.65	.84**	.49	.70	.42	.63
50%	.74*	.71*	.54	.89**	.33	.75*	.56	.61
55%	.37	.76*	.51	.91**	.63	.76*	.60	.61
60%	.83**	.79*	.42	.93**	.40	.69	.68	.57
70%	.93**	.25	-.16	.94**	.66	.71*	.77*	.75*
75%	.91**	.15	.35	.95**	.61	.77*	.82*	.79*
Width of round[h]	.36	.66	.15	.91**	.38	.71*	.73*	.84**
Width of round (dorsal)[i]	.41	.91**	.61	.85**	.23	.60	.85**	.86**
Wt. trimmed round	.93**	.93**	.82*	.88**	.58	.45	.80*	.46
Length of hind leg[j]	.85**	.93**	.66	.72*	.84**	.28	.61	.53
Length of vert. column[k]	.78*	.93**	.64	.82*	.71*	.30	.17	-.04
(Vert. column length) x (LD area - 12th rib)[l]	-.14	.59	.20	.82*	.82*	.31	.76*	.52

[a]Muscle surface exposed when rump was removed from round.
[b]Muscle surface exposed by a cut made parallel to the round-rump removal surface and at a point seventy-five percent of the distance from the hock joint to the anterior edge of the aitch bone.
[c]Semimembranosus. [d]Biceps femoris. [e]Semitendinosus. [f]Longissimus dorsi.
[g]Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the hock joint to the anterior edge of the aitch bone.
[h]Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.
[i]Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of the aitch bone and just below the fat collar to the outside of the round.
[j]Length measured from the anterior edge of aitch bone to the highest point on the tarsal bones in the hock joint.
[k]Length measured from anterior edge of first thoracic vertebra to posterior edge of last lumbar vertebra.
[l]Product of the vertebral column length and the area of the longissimus dorsi at the twelfth rib.
*Significant at the 5% level of confidence. **Significant at the 1% level of confidence.

predicting the ST weight in the early parts of the feeding period. The product of the vertebral column length and the rib eye area were significantly correlated with the ST weight in groups IV (r = .82), V (r = .82) and group VII (r = .76).

Relationships between the weight of the BF and various muscle areas and carcass measurements are presented in Table 16. The area of the BF at the RS was highly related to the BF weight in more groups than any other muscle area studied. The RS area of the BF was closer to the thickest part of the muscle than the 75% measurement. The high positive correlations through most of the feeding period indicates that as the area of the BF at the RS increases, so does the weight of the muscle. The area of the ST at the RS was also a good indicator of the BF weight in much of the feeding period. In groups IV through VII, the area of the LD was highly correlated with the BF weight.

Correlation coefficients between the BF weight and the round circumference measurements were varied in magnitude. Group VII correlations between the BF weight and the circumference of round were more significant than the correlations of other groups. No particular circumference measurement was superior in estimating the weight of the BF. This is probably due to the fact that the largest portion of the BF occurs in sections of the round (rump on) which were not encompassed by the circumference measurements.

The width of round and width of round (dorsal) were fairly accurate in predicting the BF weight. The correlations in group I for these variables were low and nonsignificant. Length of hind leg was highly significantly correlated to the BF weight in group II (r = .91) and in group V (r = .95), and significantly correlated in group IV (r = .74). After group V the correlation coefficients gradually decreased to the end of the feeding

Table 16. Simple correlation coefficients between the weight of biceps femoris and muscle areas and carcass measurements.

Group Number	I	II	III	IV	V	VI	VII	VIII
Area SM[c] - RS[a]	.75*	.83**	.46	.48	.35	.59	.58	.52
SM - 75%[b]	-.37	.48	.47	.72*	-.07	.44	.64	.83**
BF[d] - RS	.09	.80*	.70	.79*	.90**	.84**	.92**	.67
BF - 75%	.42	.86**	-.46	.86**	.43	.54	.74*	.20
ST[e] - RS	.65	.80*	.71*	.74*	.39	.75*	.88**	.52
ST - 75%	.33	.87**	.56	.66	.16	.54	.95**	.76*
LD[f] - 12th rib	-.05	.29	.10	.70	.78*	.73*	.72*	.22
Circ. of round[g] - 40%	.61	.64	.74*	.48	.61	.68	.36	.64
50%	.50	.79*	.69	.48	.26	.71*	.54	.64
55%	.38	.86**	.58	.54	.53	.77*	.63	.71*
60%	.58	.89**	.54	.57	.36	.74*	.71*	.60
70%	.72*	.49	.20	.61	.58	.76*	.78*	.75*
75%	.64	.32	.57	.64	.65	.85**	.83**	.60
Width of round[h]	.06	.77*	-.04	.72*	.78*	.86**	.77*	.67
Width of round (dorsal)[i]	.12	.89**	.71*	.66	.60	.74*	.89**	.72*
Wt. trimmed round	.69	.94**	.70	.82*	.92**	.79*	.74*	.27
Length of hind leg[j]	.62	.91**	.49	.74*	.95**	.67	.46	.06
Length of vert. column[k]	.39	.88**	.69	.78*	.76*	.69	-.01	-.07
(Vert. column length) x (LD area - 12th rib)[l]	.12	.78*	.31	.76*	.86**	.76*	.79*	.22

[a] Muscle surface exposed when rump was removed from round.
[b] Muscle surface exposed by a cut made parallel to the round-rump removal surface and at a point seventy-five percent of the distance from the hock joint to the anterior edge of the aitch bone.
[c] Semimembranosus. [d] Biceps femoris. [e] Semitendinosus. [f] Longissimus dorsi.
[g] Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the hock joint to the anterior edge of the aitch bone.
[h] Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.
[i] Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of the aitch bone and just below the fat collar to the outside of the round.
[j] Length measured from the anterior edge of aitch bone to the highest point on the tarsal bones in the hock joint.
[k] Length measured from anterior edge of first thoracic vertebra to posterior edge of last lumbar vertebra.
[l] Product of the vertebral column length and the area of the longissimus dorsi at the twelfth rib.
*Significant at the 5% level of confidence. **Significant at the 1% level of confidence.

period. Length of the vertebral column relationships with the BF weight followed a similar pattern. The relationship with the BF weight was significant in groups II (r = .88), IV (r = .78), and V (r = .76) and then the relationship decreased to the end of the feeding period. Almost no relationship existed between the BF weight and the vertebral column length in the last two feeding groups.

The weight of the trimmed round and the product of the vertebral column length and the rib eye area were both consistently highly related to the BF weight. Correlations for both relationships were low in group VIII and nonsignificant in group I.

The product of the vertebral column length, anterior edge of first thoracic to posterior edge of last lumbar, and the area of the LD at the twelfth rib was used as an estimate of volume or a cubic measure of the LD. Correlation coefficients between this variable and the weight of the LD were generally high in most groups. The volume indicator of the LD and the LD weight were significantly related in groups II (r = .81), III (r = .74), and IV (r = .82) and highly significantly related in groups V (r = .96), VI (r = .94) and VII (r = .86). Correlations in groups I (r = .69) and VIII (r = .68) were not statistically significant, but showed a positive relationship. It can be concluded that the product of the vertebral column length and the rib eye area at the twelfth rib is a fairly accurate predictor of the LD weight.

Some of the other carcass measurements studied also showed high relationships with the weight of the LD. Weight of the trimmed round and length of the hind leg were significantly related to the LD weight in six of the eight feeding groups, while length of the vertebral column (one of the components of the LD volume indicator) was significantly related to the

LD weight in half of the groups. Width of the round was not significantly correlated with the LD weight in any group. Width of the round (dorsal) was significantly related to the LD weight in groups I (r = .72), II (r = .78) and VII (r = .81). The relationships between the LD weight and the circumference measurements were varied, but the circumference measurement at seventy-five percent of the distance from the hock joint to the aitch bone was the most highly related to the LD weight. Correlation coefficients between the LD weight and carcass measurements and muscle areas appear in Table 17.

The relationships between the muscle areas and the LD weight were generally not as high as some of the correlations between the carcass measurements and the LD weight. The area of the ST (eye of the round) at the 75% surface was more highly related to the LD weight than the other round muscle areas. The two variables were significantly related in groups III (r = .79) and IV (r = .78) and highly significantly related in groups II (r = .91) and VII (r = .88). The SM tended to be the least closely related to the LD weight of all the round muscle areas studied.

The LD area at the twelfth rib and the weight of the LD were significantly correlated to each other in groups IV (r = .81) and VII (r = .76) and highly significantly correlated in groups V (r = .97) and VI (r = .85).

A comparison of the correlations of the LD weight with LD area, the vertebral column length, and the product of this length and area points up some interesting relationships. All three variables were significantly correlated with the LD weight in groups IV and VI. The LD weight was significantly correlated with the vertebral column length and the length-area product in groups II and III, and significantly correlated with the LD area and the length-area product in groups V and VII. These relationships

Table 17. Simple correlation coefficients between the weight of the longissimus dorsi and muscle areas and carcass measurements.

Group Number	I	II	III	IV	V	VI	VII	VIII
Area SM[c] - RS[a]	-.10	.64	.08	.50	.44	.48	.65	.73*
SM - 75%[b]	.23	.67	.67	.27	.37	-.09	.45	.40
BF[d] - RS	.25	.63	.92**	.65	.88**	.27	.74*	-.29
BF - 75%	.26	.82*	-.40	.79*	.64	.35	.66	.71*
ST[e] - RS	.37	.72*	.37	.87**	.62	-.02	.88**	.61
ST - 75%	.48	.91**	.79*	.78*	.47	-.17	.88**	.63
LD[f] - 12th rib	.57	.40	.45	.81*	.97**	.85**	.76*	.42
Circ. of round[g] - 40%	.50	.77*	.71*	.65	.77*	.46	.35	.49
50%	.36	.85**	.59	.66	.63	.39	.48	.50
55%	.02	.84**	.48	.68	.78*	.41	.52	.44
60%	.52	.88**	.43	.65	.63	.45	.58	.45
70%	.43	.45	.48	.72*	.73*	.43	.68	.60
75%	.41	.56	.68	.74*	.83**	.43	.76*	.77*
Width of round[h]	.30	.50	.38	.64	.53	.59	.59	.59
Width of round (dorsal)[i]	.72*	.78*	.66	.50	.44	.64	.81*	.59
Wt. trimmed round	.44	.90**	.83**	.74*	.71*	.59	.78*	.23
Length of hind leg[j]	.15	.82**	.73*	.77*	.79*	.74*	.61	.76*
Length of vert. column[k]	-.04	.93**	.80*	.82*	.56	.80*	.17	.34
(Vert. column length) x (LD area - 12th rib)[l]	.69	.81*	.73*	.82*	.96**	.94**	.86**	.68

[a] Muscle surface exposed when rump was removed from round.
[b] Muscle surface exposed by a cut made parallel to the round-rump removal surface and at a point seventy-five percent of the distance from the hock joint to the anterior edge of the aitch bone.
[c] Semimembranosus. [d] Biceps femoris. [e] Semitendinosus. [f] Longissimus dorsi.
[g] Circumference measured at points 40, 50, 55, 60, 70 and 75 percent of the distance from the hock joint to the anterior edge of the aitch bone.
[h] Width measured with calipers from the inside of the carcass at the highest point of the aitch bone to the outside of the round.
[i] Width measured with calipers from the inside of the carcass at a point directly above the anterior edge of the aitch bone and just below the fat collar to the outside of the round.
[j] Length measured from the anterior edge of aitch bone to the highest point on the tarsal bones in the hock joint.
[k] Length measured from anterior edge of first thoracic vertebra to posterior edge of last lumbar vertebra.
[l] Product of the vertebral column length and the area of the longissimus dorsi at the twelfth rib.
*Significant at the 5% level of confidence. **Significant at the 1% level of confidence.

point to the fact that in earlier feeding periods the length is more highly related to the LD weight than is the LD area, while in later feeding periods the LD area was more highly related to the LD weight than was the vertebral column length. The combination of the length and area gave a relationship which was highly related to the LD weight throughout the feeding period. These results indicate that there is value in using a combination of the LD area at the twelfth rib and the vertebral column length rather than using either variable alone for an indication of the LD weight.

SUMMARY

Sixty-four Angus steers sired by Bardoliermere 100th and owned by Martin K. Eby, Wichita, Kansas, were used in the study. At weaning the calves were randomly divided into eight groups. Group I was slaughtered at weaning while groups II-VIII were placed on full feed. Group II was removed from the feedlot and slaughtered fifty-six days post-weaning, group III at eighty-four days, group IV at 112 days, group V at 140 days, group VI at 168 days, group VII at 196 days and group VIII at 224 days.

Slaughter weight was highly significantly correlated with the weight of the trimmed four primals in groups I to VII and significantly correlated in group VIII. Carcass weight was highly significantly related to weight of the trimmed primal weight in all groups. Length of the hind leg was the only other carcass measurement studied which was highly associated with the weight of the trimmed primals throughout the feeding period.

Carcass measurements were not strongly related to the carcass retail yield as predicted by the percent trimmed four primals, the Brungardt-Bray round prediction formula, or the U.S.D.A. regression equation. Most relationships between these variables were low and nonsignificant. No trend

or pattern of relationship throughout the feeding period was evident.

Rib eye area at the 12th rib was more consistently correlated with the 9-10-11 rib lean weight than the other carcass measurements studied. Carcass weight was significantly correlated to the weight of the 9-10-11 rib lean until the calves had been fed 140 days or through group V. Fat thickness measurements over the rib eye at the twelfth rib were not highly related to the rib cut lean weight and in group VII and VIII were negatively related to the lean weight of the 9-10-11 rib cut.

The weight of the trimmed round (rump on) and the weight of the boneless retail cuts of the round were correlated with various carcass measurements, muscle areas, and muscle weights. Correlation coefficients between the length of the hind leg and the weight of the trimmed round were consistently higher throughout the feeding period than any other variable which was related to the trimmed round weight. Relationships between the circumference of round measurements and the trimmed round weight were quite variable from group to group. Muscle areas at the round removal surface were more highly related to the trimmed round weight than the areas of the same muscles at a surface seventy-five percent of the distance from the hock joint to the anterior edge of the aitch bone. Round muscle weights were more highly correlated to the trimmed round weight than the areas of these same muscles.

The correlation coefficients between the bottom round weight and carcass measurements and muscle areas indicate that no specific measurements were outstanding for the prediction of the bottom round weight throughout the feeding period, although an apparent trend of improvement was noted during the later feeding periods for the carcass measurements of round width, round circumference, and length of hind leg. No measurement studied was highly related to the weight of the top round or the sirloin tip (or knuckle) throughout the feeding period. The heel of round appears to be more easily predicted from the variables examined in this study than any of the other retail cuts of the round that were studied. The circumference of round measurements near the hock end of the round were consistently significantly related to the heel of round weight.

Muscle development of the SM, ST, BF, and LD was studied in the eight feeding groups. Development was measured by the use of the cross-sectional area of the muscle surfaces and the weights of the dissected muscles. The muscles went through two weight growth periods. There was an increase in muscle weights from the starting period to eighty-four days on feed (group IV). The muscle weights remained about the same from group III to group IV, then went into another period of increase, from group IV to group VII (196 days on feed). During the last feeding period the muscle weight generally tapered off. The muscle area growth pattern was similar to that of the muscle weights. Muscle areas increased from group I to group IV, showed little improvement in size from group III to group IV, increased through group VII, and tapered off during the last feeding period.

The round muscle weights were more highly related to the weight of the trimmed round than to other variables studied. The weight of each round muscle was generally more related to the area of that muscle than to other areas and measures. The weight of the LD was highly related to the weight of the trimmed round and the length of the hind leg in most of the feeding groups. Relationships among the area, length and weight of the LD show that during earlier feeding periods the length (anterior first thoracic to posterior last lumbar vertebra) is more highly related to the LD weight than the LD area, while in later feeding groups the LD area is more highly related to the LD weight than the vertebral column length. The combination of the length and area gave a relationship which was highly related to the LD weight throughout the feeding period.

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BIBLIOGRAPHY

Backus, W. R., J. C. Dollohan, J. C. Taylor, G. C. Williams and H. G. Travis. 1960. Live animal values and carcass measurements as indicators of meatiness and quality in beef cattle. J. Animal Sci. 19:1231 (Abstract)

Birkett, R. J. 1963. The use of various body development indices for the prediction of the percentage of closely trimmed wholesale cuts. Master's thesis, Kansas State University.

Boughton, K. T. 1958. The relationship of certain live animal measurements to carcass muscling characteristics of beef cattle. Master's thesis, Kansas State University.

Brungardt, V. H. and R. W. Bray. 1963. Estimate of retail yield of the four major cuts in the beef carcass. J. Animal Sci. 22:177.

Cole, J. W., L. E. Orme and C. M. Kincaid. 1959. Correlation of rib eye size and separable lean of various beef cuts to separable lean of the carcass. J. Animal Sci. 18:1155 (Abstract)

Cole, J. W., L. E. Orme and C. M. Kincaid. 1960. Relationship of loin eye area, separable lean of various beef cuts and carcass measurements to total carcass lean in beef. J. Animal Sci. 19:89.

Cole, J. W., C. B. Ramsey and R. H. Epley. 1962. Simplified method for predicting pounds of lean in beef carcasses. J. Animal Sci. 21:355.

Crown, R. M. and R. H. Damon, Jr. 1960. The value of the 12th rib cut for measuring beef carcass yields and meat quality. J. Animal Sci. 19:109.

Dunn, N. K. 1960. Relationships of loin eye area and other beef carcass characteristics with trimmed wholesale cuts and fat trim. Master's thesis, Kansas State University.

Field, R. A., C. O. Schoonover, G. E. Nelms and C. J. Kercher. 1963. Evaluation of some old and new beef carcass measurements. J. Animal Sci. 22:826 (Abstract)

Goll, Darrel E., L. N. Hazel and E. A. Kline. 1961b. Relationship between some beef carcass measurements and yields of wholesale cuts. J. Animal Sci. 20:264.

Goll, Darrell E., E. H. Kline and L. N. Hazel. 1961a. Influence of beef carcass grade and weight on yield of wholesale cuts and carcass measurements. J. Animal Sci. 20:260.

Gottsch, A. H. 1962. Relationships of muscle, fat, bone and some physical measurements to beef carcass cutability. Master's thesis, Kansas State University.

Green, W. W., G. L. Jesup and F. E. White. 1955. Intercorrelations of weight of wholesale cuts of beef carcasses. J. Animal Sci. 14:1059.

Hankins, O. G. and Paul E. Howe. 1946. Estimation of the composition of beef carcasses and cuts. U.S.D.A. Tech. B. 926.

Hedrick, H. B., W. E. Meyer, M. A. Alexander, J. F. Lasley, J. E. Comfort, A. J. Dyer and H. D. Naumann. 1963. Indices of meatiness in beef. Mo. Ag. Exp. Sta. Res. Bul. 820.

Hopper, T. H. 1944. Methods of estimating the physical and chemical composition of cattle. J. Agr. Res. 68:239.

Kropf, D. H. 1959. Relationships of certain muscle and bone characteristics in beef carcasses. J. Animal Sci. 18:1154 (Abstract)

Luitingh, H. C. 1962. Development changes in beef steers as influenced by fattening, age and type of ration. J. Ag. Sci. 58:1.

Murphy, C. E., D. K. Hallet, W. E. Tyler and J. C. Pierce. Estimating yield of retail cuts from beef carcasses. J. Animal Sci. 19:1240 (Abstract)

Naumann, H. D. 1952. A recommended procedure for measuring and grading beef for carcass evaluation. Proc. Fifth Annual Reciprocal Meat Conference. 5:108.

Orme, L. E. 1958. Methods for estimating carcass characteristics in beef. Ph.D. thesis, Michigan State University.

Orme, L. E., J. W. Cole, C. M. Kincaid and R. J. Cooper. 1960. Predicting total carcass lean in mature beef from weights of certain entire muscles. J. Animal Sci. 19:726.

Orme, L. E., A. M. Pearson, W. T. Magee, and L. J. Bratzler. 1959. Relationship of live animal measurements to various carcass measurements in beef. J. Animal Sci. 18:991.

Ramsey, C. B., J. W. Cole and C. S. Hobbs. 1962. Relation of beef carcass grades, proposed yield grades and fat thickness to separable lean, fat, and bone. J. Animal Sci. 21:193.

Snedecor, G. W. 1956. Statistical Methods. (5th ed.) The Iowa State University Press. Ames, Iowa. P. 174.

Thornton, John and Richard Hiner. 1963. Volume of beef round related to carcass composition. J. Animal Sci. 22:829 (Abstract)

Wellington, G. H. 1953. Recommended procedure for cutting beef. Proc. Sixth Annual Reciprocal Meats Conference 6:73.

Woodward, R. R., F. T. Rice, J. R. Quesenberry, R. L. Hiner, R. T. Clark and F. S. Wilson. 1959. Relationships between measures of performance, body form, and carcass quality of beef cattle. Mont. Agric. Exp. Sta. Bul. 550.

Zinn, Dale, R. H. Durham and Robert Stovall. 1963. Muscle growth and development in the beef animal during the feeding period. J. Animal Sci. 22:829 (Abstract)

EFFECT OF LENGTH OF FATTENING PERIOD ON MUSCLE DEVELOPMENT OF BEEF ROUND AND EVALUATION OF VARIOUS CRITERIA OF CARCASS MUSCLING

by

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AN ABSTRACT

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ABSTRACT

Sixty-four Angus steers sired by Bardoliermere 100th and owned by Martin K. Eby, Wichita, Kansas, were used in the study. At weaning the calves were randomly divided into eight groups. Group I was slaughtered at weaning while groups II-VIII were placed on full feed. Group II was slaughtered fifty-six days post-weaning and the remaining groups at twenty-eight day intervals thereafter.

Slaughter weight, carcass weight, length of hind leg, length of vertebral column, six round circumference measurements, width of round, width of round (dorsal), rib eye area, fat thickness over the rib eye, and shank circumference were obtained. Weights of the trimmed four primals and the retail cuts of the round, muscle weights of the semimembranosus (SM), semitendinosus (ST), biceps femoris (BF), and longissimus dorsi (LD), and the cross-sectional areas of the SM, ST, LD, and BF were taken. The 9-10-11 rib cut was physically separated into lean, fat and bone.

Slaughter weight was highly significantly correlated with the trimmed four primals weight in groups I to VII and significantly correlated in group VIII. Carcass weight was highly significantly related to the trimmed primal weight in all groups. Length of the hind leg was highly associated with the weight of the trimmed primals throughout the feeding period.

Carcass measurements were not strongly related to the carcass retail yield as predicted by the percent trimmed four primals, the Brungardt-Bray round prediction formula, or the U.S.D.A. regression equation and no trends or patterns were evident.

Carcass weight was significantly correlated to the 9-10-11 rib lean weight until the calves had been fed 140 days. Fat thickness measurements over the rib eye were not highly related to the rib cut lean weight.

Correlation coefficients of the weight of the trimmed round (rump on) with length of hind leg were consistently higher than with circumference of round. Round muscle weights were more highly correlated to the trimmed round weight than were areas of these same muscles.

The circumference of round measurements near the hock end of the round were consistently significantly related to the heel of round weight. No carcass measurement or muscle area was consistently related to the top round, bottom round, or the sirloin tip weights.

Muscle development, as measured by muscle weights and muscle areas, went through two growth periods, from zero to eighty-four days and from 112 to 196 days. Muscle development tapered off during the last period.

The weight of each round muscle was generally more related to the areas of that muscle than to other areas and measures. During earlier feeding periods the LD length (anterior first thoracic to posterior last lumbar vertebra) was more highly related to the LD weight than the LD area, while in later feeding groups the LD area was more highly related to the LD weight than the length. The combination of the length and area gave a relationship which was highly related to the LD weight throughout the feeding period.