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EFFECT OF CONFORMATION ON BOVINE MUSCLE YIELD

by

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Introduction

Effect of Conformation on Bovine Muscle Yield

Traditionally, conformation has been scored by federal meat graders, who evaluate overall shape of the carcass with little attention paid to the composition of that shape. During this evaluation process, thickness, plumpness, and fullness of the various parts of the carcass are analyzed.

Traditionally, slight attention has been paid to whether these dimensions were due to heavy muscling in the absence of fat deposits or if they were caused by moderate muscling and heavy fat deposits.

Finished cattle that have a moderate to excessive layer of external fat have received more favorable conformation scores than equally heavily muscled carcasses that display limited layers of external fat. This has caused many researchers to find and report a poor relationship between conformation and carcass cut-out.

With the above in mind, this study was designed with the following objectives:

(1) To select live cattle of superior conformation by visual appraisal.

(2) To determine effects of conformation on quantity of muscle yield.

(3) To determine effect of conformation on type of muscle yield.

(4) To determine effect of conformation on length, circumference and weight of certain muscles and muscle groups.

CHAPTER I

Review of Literature

Heritability of Carcass Characteristics

Many researchers have reported that most carcass characteristics are highly heritable. Knapp and Nordskog (1946) reported that heritability of rate and efficiency of gain and of live weight at several ages were in general highly heritable in beef cattle. Knapp and Nordskog (1946), using 177 steer calves from 23 sires at the U. S. Range Livestock Experiment Station estimated the heritability of weaning score (.53), slaughter grade (.63), carcass grade (.84), dressing percentage (.01), and longissimus dorsi area (.69). These writers concluded that even though measures of quality of product in beef cattle were less highly heritable than measures of growth, successful selection for measures of product quality can still be accomplished.

Dawson, Yao, and Cook (1955), who studied the heritability for five growth characteristics reported that birth weight (.506), days to weaning (.451), and days to slaughter weight (.566), were highly heritable and showed more promise to improvement by selection than did width of hip, length of body, length of coupling and width of shoulder.

These same workers also reported high heritability for slaughter grade (.583), carcass grade (.667), and dressing percentage (.691). In studying nineteen body measurements these workers reported height of withers, width between eyes, width of muzzle and depth of chest had high heritabilities of (.401 to .655) and could thus be changed with selection. The remaining live animal measurements were found to be low enough in heritability (0.00 to .335) to be of questionable value in a selection program.

Enfield and Whatley, Jr. (1961) studied 531 swine carcasses and estimated the heritability of the following carcass traits. The means are as follows: length (29.2), carcass backfat thickness (1.66), and loin area (4.05). They also determined the phenotypic and genetic correlations between these traits.

Phenotypic and genetic correlations calculated between these three traits on an intra-season, intra-station basis were all negative but small in absolute magnitude.

Cox (1964) studied the heritability of backfat thickness in 7642, 154-day old Duroc and Hampshire pigs and reported the heritability of differences within breeds of (0.25). This is about half the value reported by Dickerson (1947) who found the heritability of carcass backfat to be (0.54). Cox (1964) explained the lower heritability estimate found as due to measuring backfat at a constant age causing an increase in the environmental component among pigs within litters.

Early work at Beltsville by Sheets (1932) and at the Minnesota Station by Winters and McMahon, (1933) showed definitely that cattle varied in ability to grow, in efficiency of gains and in quality of final product as measured by selling price. On the presumption that these observed differences were, at least in part, hereditary, preliminary proposals for record of performance procedures for beef cattle were made.

Knapp and Nordskog (1946), using data from the U.S. Range Livestock Experiment Station, Miles City, Montana, presented the first estimation known to have been made of heritability of quantitative traits in beef cattle. They reported small to moderate estimates for birth and weaning weights, and extremely high heritabilities for gains during a postweaning feedlot test, for efficiency of gain during the test, and for final weight at the end of test. Heritabilities were above 50 for weaning conformation score, slaughter steer grade, carcass grade and area of rib eye muscle. Several of these estimates approached 100, thus appearing to be unrealistically large. The writers postulated that extremely high heritabilities were possible due either to 1) sampling error due to the relatively small number of observations or 2) the possibility that some environmental effects had been confused with hereditary effects. Since 1946, numerous studies of the heritability of economic traits in beef cattle have been made.

Table 1 is an attempt to summarize studies known to have been reported to date.

Carcass Traits	Number of Estimates	Average Estimate	Range of Estimates
Dressing Percent	2	71	69-73
Carcass Grade	5	34	30-84
Rib Eye Area	3	69	69-72
Tenderness	2	61	41-81
Weaning Conformation Grade	16	26	0-53

Two studies, Kincaid and Carter (1957) and Shelton, Cartwright, and Hardy (1957) have involved the mating of selected high and low gaining bulls to equivalent groups of cows with the progeny being fed out under standardized conditions and their performance compared with their sires. Both tests indicate conclusively that rate of gain is a heritable characteristic with heritability figures in the neighborhood of 40. The results of Winters and McMahon (1933) and of Knapp and Baker (1944) indicated that rate and efficiency of gain were rather highly correlated in beef cattle with rate of gain accounting for 70 to 80% of the total variation in efficiency of gain, provided the animals under test were fed through a weight-constant period. This generalization has been confirmed by a number of workers.

Cundiff *et al.* (1964) estimated heritabilities in beef cattle of carcass weight per day of age (.39), rib-eye area (.73), backfat thickness (.43), carcass quality grade (.62), carcass yield grade (.36), and estimated percent retail cuts (.40). Their conclusions were that these carcass traits could be successfully selected for.

Apparently carcass traits are of moderate to high heritability and offer real possibilities for improvement through selection.

Growth

A knowledge of growth is necessary when studying conformation related to composition.

Meek (1901), Brady and Ragsdale (1924), and Lush (1928) studied external body measurements and live weight. The conclusion reached was that live weight increased at a faster rate than any other single body measurement. They also stated that linear skeletal measurements such as measurements of skull and height measurements over the shoulder and rump increased at a slower rate than measurements of fat and muscle mass. They found that the skeleton was better developed at birth than were muscle and fat masses which constitute the greater proportion of total body mass at normal slaughter weight.

Hammond (1932), McMeekan (1941), Wallace (1948) and Palsson and Verges (1952) conducted studies in which they completely dissected swine and sheep carcasses. Their findings agreed that a primary growth"wave"occurs from the cranium to the facial parts of the head and posteriorally to the lumbar region. A secondary "wave" starts in the metacarpals and metatarsals and continues down toward the digits and upward along the limbs to the lumbar region.

Butterfield (1963) dissected beef cattle of 3 breed types at various stages of development using as a control group pre-natal, but near full term calves. From this study he determined the following categories of muscles: early developing, late developing, very late developing, and average developing. The early developing muscles were those which at birth had a weight relative to total carcass muscle that was greater than the same ratio in the mature animal. Muscles in this category included the intrinsic muscles of the forelimb, and the distal intrinsic muscles of the hind limbs. Late developing muscles were those of the abdominal and proximal muscles of the hind limbs. The intrinsic muscles of the neck and thorax and muscles of the neck and thorax which are attached to the thoracic limb fall in the category of very late developing muscles. These do not increase relative to total carcass muscle until after maturity is reached. The muscles surrounding the spinal column do not change in ratio to total carcass muscle and thus are classified as average developing muscles. This worker reported no difference in the proportion of these muscles between the breed types studied.

Hiner and Bond (1971) utilizing 51 Angus steers slaughtered at 6, 12, 18, 24, 30 and 36 months, studied the growth of muscles, separable lean and separable fat in beef steers. These steers were randomly grouped into three groups treated as follows: Group 1, full fed; Group 2, restricted to 0.34 to 0.50 kg of grain per day; Group 3, fed the same as Group 2 until 180 days before slaughter, then full-fed. Significant differences were found in slaughter and chilled carcass weights between the three groups of animals at each age period except 36 months; whereas, dressing percents were significantly different only at 6, 30, and 36 months, but not at 12, 18, and 24 months. Group 2 animals had the lowest dressing percent until 36 months of age, and Group 3 were intermediate except at 18 and 36 months of age. Rate of muscle growth varied among age groups regardless of feeding regime. The psoas major and semitendinosus muscle tended to increase in weight more rapidly than the rectus femoris and adductor muscle. The weight of muscles and weight of separable lean increased more rapidly in Groups 2 and 3 than in Group 1. However, the increase in separable carcass fat weight was more rapid in Group 3, increasing 12.49 times from 6 to 36 months. The most rapid increase in muscle weight occurred between 6 and 12 months for all three groups.

The weight of the psoas major, biceps femoris and triceps brachii increased in proportion to total lean as the animal matured. The semitendinosus muscle was approximately the same proportion of the total lean throughout the growth period. The longissimus, semimembranosus, rectus femoris and adductor muscles decreased in their proportion of total lean as the animals matured.

Carcass dissection studies by Hammond (1932) and McMeekan (1940) have established relationships between quantity of muscle and bone and the effect of animal maturity upon muscle development. The loin was found to be the latest developing region and McMeekan (1950) found strong positive correlations between percent bone and muscle.

Fattening

Hankins and Titus (1939) stated that a young growing animal is composed of protein and water for the most part; whereas, a mature one is composed mainly of fat. They noted that one obvious change with growth and fattening is the increase in ratio of carcass weight to weight of the entire body. These workers indicated that in beef, the percent rib, short loin, plate and flank increased as the animal fattened and the percent round, sirloin and foreshank decreased. There was little or no change in percent chuck and rump.

Weiss et al. (1971) studied 44 Poland China barrows, 22 from a lean strain and 22 from a fat strain. Carcass dissection and proximate analysis showed selection for muscling resulted in increased muscle and protein deposition that decreased as weight increased from 1 kg. to 137 kg. Total fat deposition was greater in the fat strain and increased significantly in both strains as body weight increased. Intra-muscular fat deposition increased at a faster rate in the lean strain with increasing weight to 91 kg.

Warner et al. (1934) studied development of swine and indicated that as the Porcine grows and fattens, percent of ham, loin, shoulder, and head decreases but bacon and fat trim increases.

Linear and Visual Live Measurements

Gregory et al. (1962, 1964) and Wilson et al. (1964) reported on the extent to which carcass traits can be predicted from live characteristics in beef cattle. Their data included use of subjective techniques of appraisal in selecting breeding stock from relatively homogeneous populations under similar feeding regimes. These workers concluded that subjective live scores can account for only 20 to 40% of the variations in carcass traits and are of only moderate value in ranking individual animals for selection from a breeding population.

Lewis, Suess and Kauffman (1969) selected 55 cattle, 55 swine and 24 lambs to represent different market weights and types. The animals were subjectively evaluated and slaughtered. These workers concluded that live weight was not a reliable indication of carcass cutability measurements, and dressing percent and loin eye area were not easily detected. Approximately 80% of the variation in lamb grades could be associated with live estimates; whereas the value was 47% for cattle, perhaps due to the difficulty in estimating marbling.

Gregory _et al_. (1964) subjectively evaluated 204 steers for live and carcass traits at about 452 days of age. Live estimates were made of dressing percent, fat thickness at the 12th rib, rib eye area at the 12th rib, percent kidney fat, cutability (percent primal cut yield) and slaughter grade. Carcass data obtained on these steers included carcass weight, fat thickness at the 12th rib, rib eye area at 12th rib, estimated percent kidney fat, carcass grade, estimated cutability, and actual cutability. These workers concluded that trained personnel can estimate group means accurately for cutability and carcass grade in live cattle. Results also showed that live cattle can be appraised more precisely for carcass cutability factors than for carcass quality grade.

Muscle to Carcass Composition Relationship

Presently much emphasis is given to the meat-type steer and its identification alive and in the carcass. In the past, cross sectional area or the "Shape Index" of the _longissimus dorsi_ muscle has been extensively used as an index of total muscling of a particular carcass. Palsson (1939) indicated that the degree of muscle development could be estimated best by observing longissimus cross-sectional area at the last rib, since this area is the last to reach its full development as explained by the body growth gradient theory.

Hammond (1932), McMeekan (1941), Wallace (1948), Palsson and Verges (1952), and Branaman (1940) all working with pork and lamb carcasses, reported the area of loin eye to be a fairly good index of total carcass lean.

Palsson (1939) reported correlation coefficients of 0.77 in lambs and 0.81 in yearling sheep between weight of carcass lean and the depth plus the length of loin eye.

McMeekan (1941) working with 20 pigs, bacon of 200 lb. weight reported a correlation of 0.84 between the same factors. Both Palsson (1939) and McMeekan (1941) obtained a better estimate of total carcass lean when carcass length was combined with the depth and length of loin eye.

Kline and Hazel (1955) reported the positional variability of loin eye area in pork carcasses. Data on cut out and chemical analysis of pork carcasses suggest that loin eye is not highly related to total muscling of the entire carcass.

Cole, Orme and Kincaid (1960) studied area of loin eye, carcass weight, the separable lean of a particular beef cut and various linear carcass measurements to evaluate their usefulness for predicting total carcass leanness. Variation in area of the loin eye accounted for only 18% of the variation of separable carcass lean, and 5 to 30% of the variation in the separable lean of the more valuable cuts. Likewise, the relationship of various linear carcass measurements with either loin eye area or carcass separable lean was quite low. Carcass width and circumference measurements were more highly related to loin eye area, while various linear measurements descriptive of carcass length were more closely related to total lean. Bone weight of the entire carcass was highly related to total separable carcass lean (r = 0.75). Separable lean of a particular cut of beef was found to be more descriptive of carcass leanness or muscling than either the area of loin eye or various carcass measurements. Correlation coefficients between total separable carcass lean and lean of various wholesale cut were 0.95 with round, 0.93 with chuck, 0.81 with foreshank, 0.80 with sirloin, and 0.75 with shortloin. Using regression equations, total carcass lean was found to increase by 2.94 and 20.43 pounds for each pound increase in separable round or foreshank lean. The high relationship of lean content in these and other beef cuts (especially the round), to the total lean of the carcass is an indication of their usefulness to predict total carcass muscling in a particular beef carcass.

Wythe, Orts and King (1961) studied the relationship of bone to muscle in beef carcasses. They reported that strong positive correlations obtained indicated that bones of an animal developed proportionally in length and weight and suggest that a real association existed between bone thickness and muscling of the cattle studied.

Kemp and Barton (1969) studied 126 lamb carcasses of the prime, choice, good, and utility grades. Cut-out values showed that leg, shoulder, shank, neck, kidney and waste increased as a percent of carcass from prime to the utility grade. Loin, rack, breast, flank, and pelvic fat percentage decreased, percent separable fat of rack decreased and percent separable muscle and bone of the rack increased with each lower grade.

Carcass Traits and Their Influence on Carcass Retail Yield

Pearson et al. (1970) using data from 1,002 hogs related live and carcass value to other carcass parameters. They reported that a single measure of backfat thickness taken at the last lumbar vertebra more accurately reflected carcass value than did average backfat measurement. Similarly, area of the M. longissimus at the 10th rib was a better indication of carcass value than area at the last rib. Carcass length was shown to have little relationship to percent lean cuts, percent primal cuts or carcass value. A regression equation incorporating live slaughter weight, dressing percent and backfat thickness at the last lumbar vertebra gave the best estimate of live value, accounting for 72% of the variation. Similarly, use of cold carcass weight, backfat thickness at the last lumbar vertebra, and area of the M. longissimus at the 10th rib accounted for 69% of the variation in carcass value.

Kemp, Lambuth, and Barton (1970) working with 126 New Zealand lamb carcasses, varying from 7.98 to 22.90 kg., measured and cut them into wholesale cuts. The right side and several selected cuts were analyzed for water, fat, ash and protein content. All linear measures were related to carcass weight and some were highly correlated with percent fat in the side. Percent rack and loin were directly related to percent fat in the side while percent leg and shank were directly related to percent water, ash and protein in the side.

Percent shoulder, rack, loin and leg were all significantly ($P < .05$) correlated with the respective chemical components of the side. Composition of the rack usually had the highest relationships with carcass composition components. Carcass weight, percent or weight kidney and pelvic fat, and U.S.D.A. grade all had highly significant ($P < .01$) and positive correlations with percent fat in the side and ($P < .01$) negative correlations with percent water, ash and protein in the side.

Fat Thickness

The most accurate predictors of muscle and fat in beef carcasses reported to date include fat thickness over the longissimus dorsi between the 12th and 13th ribs, carcass weight, area of longissimus dorsi and quantity of kidney fat. Brungardt (1962) reported a correlation coefficient between area of longissimus dorsi and percent retail yield of 0.45 which was in agreement with work by Cole et al. (1960). Thus, Longissimus dorsi area accounted for 20% of the variation in retail yield.

Backfat thickness has been used as a measure of carcass fatness for many years, although proof of the existence of such relationship was poorly documented until Hankins and Ellis (1934) showed that backfat thickness and percentage of either extract in the carcass were related.

Brown et al. (1951), Whiteman et al. (1953), and Pearson et al. (1956) found that specific gravity of the carcass was a more precise measure of leanness than was backfat thickness. Pearson et al. (1956) studied the use of the fat-lean ratio in a cross section of the rough loin at the last rib as a possible measure of carcass leanness. Correlation coefficients of approximately 0.60 between the fat-lean ratio and several measures of carcass cut-out indicated the relationship may be high enough to be useful.

Spurlock and Bradford (1965) reported that specific gravity was very accurate for estimating the percent fat of carcasses that varied considerably in fatness. This agrees with the findings of McManus and Goldstone (1965) who reported a significant correlation between specific gravity of the half carcass and percent fat of the carcass. Munson (1966) suggested that specific gravity data should be combined with other carcass measurements to provide reliable estimates of carcass composition.

Aunan and Winters (1952) and Kline and Hazel (1955) used a carcass coring device to estimate the proportion of fat and lean tissue of swine carcasses. These workers indicated that the ratio of fat to lean tissue in the core samples taken at a 5th-6th rib location is highly associated with the ratio of fat to lean tissue of the carcass.

Loin Eye Area

Area of *longissimus dorsi* muscle and thickness of subcutaneous fat over this muscle are two measurements used most frequently in beef carcass evaluation. A procedure for determining *longissimus dorsi* area and subcutaneous fat thickness was described by Naumann (1952). Stouffer *et al*. (1961) proposed that a standardized ribbing procedure be adopted to minimize differences in *longissimus dorsi* area due to inconsistent ribbing practices.

Hedrick *et al*. (1965) made *longissimus dorsi* muscle and subcutaneous fat measurements on 1096 good and choice steer carcasses weighing from 158.8 to 385.6 kg. Muscle area increased approximately 50%, and subcutaneous fat thickness increased approximately twofold from, the 158.8

to the 385.6 kg. weight group. Differences in subcutaneous fat thickness measurements were 2 to 3 times more highly associated with the variation in retail yield as were *longissimus dorsi* area measurements. *Longissimus dorsi* muscle measurements were more highly associated with weight than with percent retail cuts. Conversely, subcutaneous fat thickness measurements were more highly associated with percent than with weight of retail cuts.

Cole *et al*. (1960) reported positive correlation coefficients of 0.40 and 0.60, respectively, between the *longissimus dorsi* muscle area and separable carcass lean.

Brungardt and Bray (1963) indicated that 20% of the variation in retail yield could be attributed to the differences in area of the *longissimus dorsi* muscle. It has been generally concluded by Briskey and Bray (1964) that influence of area of *longissimus dorsi* muscle upon retail yield is small compared to that of fat.

McReynolds and Arthaud (1969) reported a correlation of 0.95 between the *longissimus* muscle estimated before slaughter and the area measured on the carcass.

Carcass Weight

Butterfield (1962) reported than an increase in carcass weight had a depressing effect upon total retail yield. This is in agreement with Brungardt and Bray (1963) who reported that heavier carcasses contained more fat per unit of carcass weight than lighter ones. Cole *et al*. (1962) also indicated as carcass weight increases the average percent of steak and roast meat decreased and percent waste increased.

Swiger *et al*. (1964) reported the correlation coefficient between carcass weight and percent retail yield to be -.48. Thus, researchers are in general agreement that as weight increases percent muscle decreases and percent fat increases.

Conformation

Historically, considerable emphasis has been placed on conformation in the selection, production and marketing of beef cattle. Conformation is included in U.S.D.A. beef carcass grade standards (1965) because "superior conformation implies a high proportion of weight of the carcass or cut in more valuable parts". Subjective assessment of conformation is influenced by muscle thickness, depth and length, and to a variable extent by subcutaneous and intramuscular fat deposits. Some disagreement is found in the literature as to relationship between carcass conformation and yield of retail cuts.

Pierce (1957) reported a small but significant positive relationship between conformation grade and yield of closely trimmed retail cuts from the beef round, loin, rib, and chuck. Likewise, Martin *et al*. (1966) observed a slight advantage of choice vs. standard conformation in yield of thick muscles. Briedenstein (1962) reported no significant relationship between conformation and yield of retail cuts of good and choice steer carcasses, but a slight positive relationship was observed between conformation and retail yield of heifer carcasses. Tyler et al. (1964) observed no significant difference in yield of boneless retail cuts from carcasses differing in conformation from low good to high choice having similar U.S.D.A. yield grades.

Hedrick, Stringer and Krause (1969) using 48 average choice and 36 average good conformation steer carcasses, studied the effect of carcass conformation, hot carcass weight and fat thickness at the 12th rib on yield of uniformly trimmed retail cuts. Average choice conformation carcasses yielded a higher percent ($P < .05$) of total retail cuts than average good conformation carcasses mainly due to a higher yield of minor retail cuts and less bone. No significant differences were noted in percent of retail cuts from the primal wholesale cuts or percent thick retail cuts, roast and steaks attributable to conformation. Carcass weight had no significant effect. Fat thickness at the 12th (1.31 to 2.0 vs. 0.8 to 1.3 cm) had a more consistent effect on weight and percent of retail cuts than conformation or carcass weight.

Hankins, Knapp, and Phillips (1943) studied muscle-bone ratio in 135 steers. These early workers reported that no significant relationship was found within types between muscle-bone ratio and percent of separable fat in the carcass. In addition, no significant relationship found between live animal measurements and the muscle-bone ratio, and they concluded that selection could not be made on the basis of conformation as evaluated by such measurements.

Pierce (1957), Butler (1957), Kidwell et al. (1959), and Goll et al. (1961), have shown that finish exerts more influence than conformation on yields of high value portions.

Murphey et al. (1960) reported that measures of finish were four and one-half times as important as conformation scores in predicting yields of closely trimmed wholesale cuts.

Martin et al. (1966) working with ten low choice and ten high standard conformation steer carcasses found that standard conformation carcasses produced longer, wider, thinner muscles and muscle systems than choice carcasses. However, the advantages in length and width for the standard carcasses disappeared when the muscles of less than 2 inches thickness were excluded. The most striking advantages of choice conformation were found to be in the ratio of total muscle to bone, and thick, high value muscle to bone. Thus, among carcasses of approximately the same degree of finish, carcasses grading higher in conformation were superior in terms of thick steak and roast cuts (at least 2 inches thick) and total lean to the lower grading conformation carcasses.

Regression Equations Used for Predicting Carcass Retail Yield

Hankins and Howe (1946) found composition of the 9-10-11th rib cut to be closely correlated with the composition of the carcass. Additionally these workers developed equations for estimating carcass composition based upon the composition of this three-rib section. Hankins (1947) developed prediction equations for lamb using separable fat, lean and bone of a wholesale rib cut containing 9 ribs (4 through 12).

Cole *et al*. (1960) found a correlation coefficient between bone weight and total pounds separable muscle of the beef carcass of 0.75. Individual muscle weights and total separable muscle in the carcass have been studied in cow carcasses by Orme *et al*. (1960). Holding slaughter weight constant, the partial regression coefficients between weight of separable muscle in the carcass to muscle weight was: *biceps femoris*, 0.97; sirloin tip muscle group, 0.82; and *longissimus dorsi*, 0.79.

Crown and Damon (1960) have reported a highly significant association between the composition of the 12th rib cut and the 9-10-11th rib.

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CHAPTER II

Effect of Conformation on Edible Portion and Quantity of Steak and Roast Yield of Carcasses and Wholesale Cut Yield in Bovines

Subjective evaluation of conformation has been widely criticized as a means of measuring muscling in live animals and carcasses. Most research has shown low positive to highly negative relationships between conformation and measures of muscling.

Pierce (1957) reported a small but significant positive relationship between conformation grade and yield of closely trimmed retail cuts from the beef primals. Likewise, Martin et al. (1966) observed a slight advantage in yield of thick (at least 2 inches thick) vs. thin muscles when comparing choice and standard conformation. Working with ten low choice and ten high standard conformation steer carcasses, these workers found that standard conformation carcasses produced longer wider thinner muscles and muscle systems than did choice carcasses. However, the advantage in length and width for the standard carcasses disappeared when the muscle less than 2 inches was excluded. The most striking advantages of superior conformation were found to be the ratio of total muscle to bone, and "thick, high value muscle" to bone. Among carcasses of approximately the same degree of finish, the carcasses grading higher in conformation were superior in terms of "thick meat" and total lean compared to the lower grading conformation carcasses.

Briedenstein (1962) reported no significant effect of conformation on yield of retail cuts when comparing good and choice conformation using both steer and heifer carcasses. However, a slight advantage in retail yield was observed for choice conformation when using only heifer carcasses.

Tyler et al. (1964) observed no significant difference in yield of boneless retail cuts from carcasses differing in conformation from low good to high choice but having similar USDA yield grades.

Hedrick, Stringer, and Krause (1969), using 48 average choice and 36 average good conformation steer carcasses, studied the effect of carcass conformation, hot carcass weight, and fat thickness at the 12th rib on yield of uniformly trimmed retail cuts. Average choice conformation carcasses yielded a higher percent ($P < .05$) of total retail cuts than average good conformation carcasses mainly due to a higher yield of minor retail cuts and less bone. No significant differences in percent of retail cuts from the primal wholesale cuts or percent "thick" retail cuts, roast and steaks were attributable to conformation.

Experimental Procedure

Four groups of 20 steer carcasses were selected and used in this study. A summary of specifications and selection criteria is presented in table 2.

Carcasses were selected at packing plants in the area and the left side purchased and brought to the Kansas State University meats lab for fabrication. The left side was cut into conventional wholesale cuts according to the procedure described by Wellington (1953) with the following two exceptions. The brisket was cut along the same line as the shank such that a square cut chuck resulted. In addition the rump was not separated from the round. The average side weight of the four groups varied by 2.2 kg. from 156.0 to 158.2 kg. (table 3). Carcass weight range was restricted so as to avoid differences in cut-out due to carcass weight.

Selection groups included two groups each of low conformation and high conformation. Groups I and II were selected with external fat thickness at random, whereas in Groups III and IV the outside fat was restricted between 0.76 to 1.02 cm.

All sides were cut into boneless, closely trimmed edible portions (0.64 to 0.76cm.). Weight of steak and roast meat muscles and muscle systems (5 cm. or thicker) from the primal cuts was determined. Ground beef was made with trim from all cuts and fat content was standardized as near 25% as possible.

Statistical Analysis

The statistical procedures followed are described by Snedecor (1956). A 2 X 2 factorial analysis with 10 carcasses per cell was used to determine treatment and interaction effects. Fisher's least significant difference (LSD) means separation procedure was used to evaluate significance of individual differences among interaction means. Simple correlation coefficients were calculated on a within treatment subclass basis and were pooled to estimate the relationship among most carcass measurements. Least squares analysis of variance (Kemp, 1970) was used to analyze all variables in which there was missing data.

Table 2. Specifications for Each of Four Groups of Beef Carcasses

Specification	Group I	Group II	Group III	Group IV
Fat thickness	Random	Random	.76-1.02 cm.	.76-1.02 cm.
Conformation (USA)	Average good or poorer	Low prime or better	Average good or poorer	Low prime or better
Weight	306.2-340.8 kg	306.2-340.8 kg	306.2-340.8 kg	306.2-340.8 kg

RESULTS AND DISCUSSION

Carcass trait means for conformation and fat thickness groups are shown in table 3. The low prime or higher conformation group was obviously higher ($P < .05$) in conformation score than was the average good or lower group. This same difference exists when studying the four groups selected within conformation and fat thickness constraints with groups I and III having lower ($P < .05$) conformation scores than groups II and IV (table 4). Final quality grade followed the same trend with those carcasses selected for higher conformation scores having higher ($P < .05$) final quality grades (tables 3 and 4). This is expected since conformation is a factor that partially determines final grade. Final quality grade was also higher ($P < .05$) in the group selected with random external fat than in those carcasses selected with restricted external fat (table 3). Carcasses that are fatter usually tend to be higher grading carcasses due to the fact that external fat thickness and length of time on feed are usually positively related.

When observing differences in external fat thickness (tables 3 and 4) the groups selected with random outside fat were fatter ($P < .05$) and those groups with higher conformation scores were also fatter ($P < .05$) especially for those selected for random fat thickness. It should be noted in table 5 that conformation and fat thickness are related at

Table 3. Conformation and Fat Thickness Group Means for Carcass Traits

Carcass traits	Conformation groups: Average good or lower	Conformation groups: Low prime or higher	P
Hot carcass wt., kg.	320.5	326.8	N.S.
Chilled side wt., kg.	156.6	157.6	N.S.
Carcass conformation[1]	17.3	22.7	<.05
Final quality grade[1]	17.9	19.6	<.05
Fat thickness, cm.	0.8	1.3	<.05
Loin eye area, sq. cm.	76.1	86.5	<.05
Kidney knob %	4.2	2.9	<.05
Yield grade	3.0	2.9	N.S.
USDA cutability[2]	49.8	50.2	N.S.

Carcass traits	Fat thickness groups: Random external fat	Fat thickness groups: Selected external fat	P
Hot carcass wt., kg.	321.1	324.7	N.S.
Chilled side wt., kg.	156.0	158.2	N.S.
Carcass conformation[1]	20.0	19.9	N.S.
Final quality grade[1]	19.1	18.3	<.05
Fat thickness, cm.	1.4	0.7	<.05
Loin eye area, sq. cm.	78.7	84.5	<.05
Kidney knob %	3.6	3.5	N.S.
Yield grade	3.4	2.5	<.05
USDA cutability[2]	49.0	51.1	<.05

[1]Carcass conformation and quality grade score: High prime = 24, average prime = 23, low prime = 22, high choice = 21, high good = 18, low good = 16.

[2]Estimated percent boneless, closely trimmed retail yield from the round, loin, rib and chuck.

Table 4. Selection Group Means for Carcass Traits

Carcass traits	Group I[1]	Group II[2]	Group III[3]	Group IV[4]
Hot carcass wt., kg.	316.4	325.7	325.5	324.0
Chilled side wt., kg.	153.8[a]	158.2[b]	159.3[b]	157.0[ab]
Carcass conformation[5]	17.6[b]	22.4[c]	16.9[a]	23.0[d]
Final quality grade[5]	18.4	19.8	17.2	19.3
Fat thickness, cm.	1.0[b]	1.8[c]	0.6[a]	0.9[b]
Loin eye area, sq. cm.	75.5[a]	81.9[b]	77.4[ab]	90.3[c]
Kidney knob %	4.3	2.8	4.0	3.0
Yield grade	3.2[c]	3.5[c]	2.7[b]	2.3[a]
USDA cutability[6]	49.3[a]	48.7[a]	50.4[b]	51.7[c]

1 Average good or lower conformation, random external fat.
2 Low prime or higher conformation, random external fat.
3 Average good or lower conformation, selected external fat.
4 Low prime or higher conformation, selected external fat.
5 Carcass conformation and quality grade score: High prime = 24, Average prime = 23, Low prime = 22, High choice = 21, High good = 16.
6 Estimated percent boneless, closely trimmed retail yield from the round, loin, rib and chuck.
a,b,c Means in the same row with different superscript letters are significantly ($P < .05$) different.

Table 5. Correlation Coefficients Pooled on a Within Group Basis Between Carcass Traits and USDA Cutability

	Carcass conformation	Quality grade	Fat thickness	Loin eye area	% Kidney knob	USDA cutability[1]
Carcass conformation	1.00					
Quality grade	0.26	1.00				
Fat thickness	0.26	0.38	1.00			
Loin eye area	0.20	-0.04	-0.52	1.00		
% Kidney knob	-0.39	0.13	0.20	-0.28	1.00	
USDA cutability[1]	-0.14	-0.62	- .68	0.38	-0.41	1.00

Correlations 0.250 are significant ($P < .05$)
Correlations 0.325 are significant ($P < .01$)

[1]Estimated percent boneless, closely trimmed retail yield from the round, loin, rib and chuck.

0.26 ($P < .05$).

Longissimus muscle area was greater ($P < .05$) (table 3) in carcasses selected for superior conformation as well as in those carcasses selected for restricted outside fat. Table 4 shows that *longissimus* muscle area in group IV was larger ($P < .05$) than all other groups. Group II was also different ($P < .05$) than group I. The two groups with the greatest mean *longissimus* muscle area were the two superior conformation groups II and IV (81.9 and 90.3 sq. cm., respectively). The data on *longissimus* muscle area in table 3 and 4 would indicate that part of the evaluation of superior conformation could have been determined by size of the *longissimus dorsi* muscle. Loin eye area is negatively related with external fat thickness (-.52). This would indicate that carcasses with greater amounts of outside fat within the same conformation constraints tended to have smaller *longissimus* muscle areas than did those with restricted outside fat. This could mean that greater amounts of outside fat can mask size of *longissimus* muscle and influence conformation score.

No significant difference was noted between the two fat thickness groups in percent kidney knob but low conformation carcasses had greater ($P < .05$) amounts of internal fat than did high conformation carcasses (table 3). The correlation between percent kidney knob and carcass conformation was negative at -.39 (table 5). This agrees with the findings of Wilson and Curtis (1893) who reported that carcasses from dairy steers which tend to have low conformation scores also had more internal fat. No significant differences were noted in percent internal fat between the four groups selected within conformation and external fat thickness constraints (table 4).

Yield grade and estimated percent cutability were not different between conformation groups but were affected ($P < .05$) by external fat thickness (table 3). The correlation between predicted cutability and external fat thickness was highly negative (-.68) (table 5). This would be expected due to the great influence of external carcass fatness on yield grade and percent cut-out. This relationship has been reported by several workers; Cole et al. (1962), Lewis et al. (1964), Hendrick et al. (1963), and Miller et al. (1965). In looking at USDA yield grade and cutability means by group in table 4, it is obvious that those carcasses selected with random external fat have less ($P < .05$) desirable yield grade and less estimated percent cut-out. Between groups III and IV, with the only difference in selection criteria being conformation, group IV with superior conformation also had ($P < .05$) the most desired mean yield grade (2.3) and the highest percent estimated cutability (51.7 percent).

Weight and Percent Wholesale Cuts

When comparing the high and low conformation groups (table 6) it should be noted that there is no significant difference in weight or percent of round, plate and flank. There is also no difference ($P < .05$) in weight of chuck but there is a difference ($P < .05$) in percent chuck with the low conformation group having 0.6% more of its carcass weight in chuck.

In studying table 6 it is apparent that the weight and percent loin and rib were higher ($P < .05$) in carcasses with low prime or higher conformation. Loins from superior conformation carcasses weighed 1.1 kg. more and made up 0.6% more of the side weight. Ribs weighed 0.9 kg. more and made up 0.5% more of the side weight (table 6). Part of these differences can be explained by the fact that the superior conformation carcasses had larger loin eyes as was seen in table 3 (10.4 sq. cm. larger).

Comparing the other cuts it should be noted that the low conformation carcasses have less ($P < .05$) weight and percent brisket than do the high conformation carcasses. However, the low conformation carcasses have greater ($P < .05$) weight and percent of shank and kidney knob (table 6).

Selecting carcasses with restricted external fat compared with random external fat resulted in a difference ($P < .05$) in the weight of the round, loin, chuck, plate and flank (table 6). Carcasses with restricted outside fat had greater ($P < .05$) weight of round (1.9 kg.), loin (0.9 kg.) and chuck (1.4 kg.) but less plate (0.7 kg.) and flank

Table 6. Conformation and Fat Thickness Group Means for Weight and Percent Wholesale Cuts

Trimmed wholesale cuts	Conformation groups					
	Average good or lower kg.	Low prime or higher kg.	P kg.	Average good or lower %	Low prime or higher %	P %
Round	34.6	35.4	N.S.	22.1	22.5	N.S.
Loin	22.8	23.9	<.05	14.6	15.2	<.05
Rib	12.9	13.8	<.05	8.3	8.8	<.05
Chuck	44.6	44.0	N.S.	28.5	27.9	<.05
Brisket	5.9	6.8	<.05	3.7	4.3	<.05
Plate	12.9	13.2	N.S.	8.3	8.4	N.S.
Shank	5.4	5.1	<.05	3.5	3.2	<.05
Flank	10.7	10.8	N.S.	6.9	6.9	N.S.
Kidney knob	6.6	4.6	<.05	4.2	2.9	<.05

Trimmed wholesale cuts	Fat thickness groups					
	Random external fat kg.	Selected external fat kg.	P kg.	Random external fat %	Selected external fat %	P %
Round	34.0	35.9	<.05	21.8	22.7	N.S.
Loin	22.9	23.8	<.05	14.7	15.1	<.05
Rib	13.4	13.3	N.S.	8.6	8.4	N.S.
Chuck	43.6	45.0	<.05	27.9	28.4	<.05
Brisket	6.4	6.2	N.S.	4.1	3.9	N.S.
Plate	13.4	12.7	<.05	8.6	8.0	<.05
Shank	5.2	5.4	N.S.	3.3	3.4	N.S.
Flank	11.4	10.2	<.05	7.3	6.4	<.05
Kidney knob	5.6	5.6	N.S.	3.6	3.5	N.S.

(1.4 kg.). When these cuts were expressed as a percent of the carcass the significant difference in the round was lost but percent loin and chuck was greater ($P < .05$) (0.4% and 0.5% respectively) in the carcasses with restricted external fat and the percent plate and flank were less (0.6% and 0.9%, respectively). This would agree with the findings of Miller et al. (1965) who concluded that yield of muscle from the flank was relatively constant but as fatness increased the flank served as a fat depot with greater and greater amounts of fat being deposited as the animal fattened. Correlation coefficients of carcass traits and weights and percents of wholesale cuts appear in tables 7 and 8. Fat thickness when compared to the weight and percent rib and flank showed a positive relationship (0.32, 0.37, rib weight and percent and 0.65, 0.67, flank weight and percent). Conversely, fat thickness when compared to the weight and percent of other primals and to total primals showed negative relationships (table 7). In the case of the relationships between fat thickness and the weight and percent round and total primals the correlations were highly significantly ($P < .01$) (table 7 and 8) negative.

In studying table 9 (groups selected for both fat thickness and conformation), group I yielded lighter weight ($P < .05$) loins than the other groups. Though the differences in loin weight between the other 3 groups were not significant, groups II and IV (high conformation groups) tended to

Table 7. Correlation Coefficient Between Carcass Conformation, Fat Thickness and Weights of Trimmed Wholesale Cuts

	Carcass conformation	Fat thickness	Round weight	Loin weight	Rib weight	Chuck weight	Total primal weight	Flank weight
Carcass conformation	1.00							
Fat thickness	0.26	1.00						
Round Weight	-0.27	-0.52	1.00					
Loin Weight	0.03	-0.13	0.49	1.00				
Rib weight	0.04	0.32	0.02	0.24	1.00			
Chuck Weight	-0.08	-0.16	0.38	0.32	0.05	1.00		
Total primal Weight	-0.16	-0.33	0.82	0.69	0.26	0.76	1.00	
Flank weight	0.22	0.65	-0.55	-0.31	0.14	-0.03	-0.35	1.00

Correlation 0.250 are significant $(P < .05)$
Correlation 0.325 are significant $(P < .01)$

Table 8. Correlation Coefficient Between Carcass Conformation, Fat Thickness and Percent Trimmed Wholesale Cuts

	Carcass conformation	Fat thickness	Round percent	Loin percent	Rib percent	Chuck percent	Total primal percent	Flank percent
Carcass conformation	1.00							
Fat thickness	0.26	1.00						
Round percent	0.19	0.60	1.00					
Loin percent	0.18	-0.09	-0.07	1.00				
Rib percent	0.15	0.37	0.05	0.15	1.00			
Chuck percent	0.07	-0.16	-0.11	-0.17	-0.29	1.00		
Total Primal Percent	-0.00	-0.48	-0.26	0.13	-0.24	0.28	1.00	
Flank percent	0.28	0.67	0.40	-0.55	0.19	-0.16	-0.58	1.00

Correlation 0.250 are significant ($P < .05$)
Correlation 0.325 are significant ($P < .01$)

Table 9. Selection Group Means for Weight and Percent Wholesale Cuts

Trimmed Wholesale cuts	Group I[1] kg.	Group II[2] kg.	Group III[3] kg.	Group IV[4] kg.
Round	33.1[a]	35.0[a]	36.0[b]	35.8[b]
Loin	22.0[a]	23.8[b]	23.6[b]	24.0[b]
Rib	12.9	14.0	12.9	13.7
Chuck	43.0[a]	44.2[a]	46.2[b]	43.8[a]
Brisket	6.1	6.8	5.7	6.7
Plate	13.1	13.7	12.8	12.6
Shank	5.4	5.0	5.5	5.2
Flank	11.5	11.2	9.9	10.5
Kidney knob	6.7	4.5	6.6	4.8
	%	%	%	%
Round	21.5	22.1	22.6	22.8
Loin	14.3	15.0	14.8	15.3
Rib	8.4	8.8	8.1	8.7
Chuck	27.9[a]	27.9[a]	29.0[b]	27.9[a]
Brisket	4.0	4.3	3.5	4.3
Plate	8.5	8.7	8.0	8.0
Shank	3.5	3.1	3.5	3.3
Flank	7.5	7.1	6.2	6.7
Kidney knob	4.4	2.8	4.1	3.0

[1]Average good or lower conformation, random external fat.
[2]Low prime or higher conformation, random external fat.
[3]Average good or lower conformation, selected external fat.
[4]Low prime or higher conformation, selected external fat.
[a,b]Means in the same row with different superscript letters are significantly ($P < .05$) different.

have greater weight and percent loin than did group I and III (low conformation group).

Group III (low conformation, restricted fat group) had more ($P < .05$) weight and percent chuck than did the other 3 groups (table 9). Groups I, II and IV each had 27.9% of their carcass weight in chuck and group III 29.0% chuck. This is possibly due to the fact that lower conformation carcasses have a greater weight and percent bone when compared to superior conformation carcasses.

These findings indicate that carcasses with superior conformation tend to have a greater weight and proportion of their weight in loin, rib, and brisket. Low conformation carcasses have a greater weight and proportion of their weight in chuck, shank and kidney knob. Part of the advantage in weight and percent loin and rib in high conformation carcasses is explained by these having an obvious advantage in size of loin eye.

<u>Weight and Percent Primal Cut Steak and Roast Yield</u>

This study shows that carcasses selected for superior conformation do yield greater amounts of steak and roast meat in the rib and loin than do poorer conformation carcasses (table 10). Conformation score also shows an effect ($P < .01$) on steak and roast meat yield from the four primal cuts (table 11 and 12). Correlation coefficients between carcass conformation, fat thickness and yields of steak and

Table 10. Conformation and Fat Thickness Group Means for Weight and Percent Primal Cut Steak and Roast Meat[1]

Primal cuts	Conformation groups: Average good or lower kg.	Low prime or higher kg.	P kg.	Average good or lower %	Low prime or higher %	P %
Round	20.3	20.7	N.S.	12.9	13.2	N.S.
Loin	12.2	12.7	<.05	7.8	8.1	<.05
Rib	5.9	6.6	<.05	3.8	4.2	<.05
Chuck	16.8	17.1	N.S.	10.7	10.9	N.S.
Total primal cuts	55.2	57.2	<.05	32.2	36.3	<.05

Primal cuts	Fat thickness groups: Random external fat kg.	Selected external fat kg.	P kg.	Random external fat %	Selected external fat %	P %
Round	19.4	21.5	<.05	12.4	13.6	<.05
Loin	12.0	13.0	<.05	7.7	8.2	<.05
Rib	6.1	6.3	N.S.	3.9	4.0	N.S.
Chuck	16.4	17.6	<.05	10.5	11.1	<.05
Total primal cuts	53.9	58.4	<.05	34.5	37.0	<.05

[1]Muscle and muscle systems of two inches or more in thickness from the round, loin, rib, chuck.

Table 11. Analysis of Variance for Weight of Steak and Roast Meat from Each Primal Cut and Total Primal Cuts

Source of Variance	d.f.	Round Steak and Roast	Loin Steak and Roast	Rib Steak and Roast	Chuck Steak and Roast	Total Primal Steak and Roast
Fat thickness	1	439.45**	92.88**	4.23	142.58	732.03**
Conformation	1	21.74	33.54*	43.81**	8.45	551.22**
Fat thickness and conformation	1	16.47	13.28	7.32*	.45	415.87*
Error	76	21.17	6.37	1.63	11.49	

** ($P < .01$)
* ($P < .05$)

Table 12. Analysis of Variance for Percent of Steak and Roast Meat from Each Primal Cut and Total Primal Cuts

Source of Variance	d.f.	Round Steak and Roast	Loin Steak and Roast	Rib Steak and Roast	Chuck Steak and Roast	Total Primal Steak and Roast
Fat thickness	1	28.05**	5.60**	0.15	8.08**	118.58**
Conformation	1	1.23	2.23*	3.19**	0.37	24.96*
Fat thickness and conformation	1	.00	3.12*	1.29**	0.63	13.49
Error	76	1.35	0.49	0.14	0.79	4.82

** $(P < .01)$
* $(P < .05)$

roast meat are given in tables 13 and 14. Fat thickness shows a highly significant ($P < .01$) negative relationship to weight and percent steak and roast meat from the round, loin, chuck and total from four primals (table 13 and 14). This agrees with the findings of Allen (1966). Correlation coefficients between conformation score and yields of steak and roast meat were non-significant and near zero (table 13 and 14). This simply indicates that when conformation is evaluated without taking external fatness into consideration it is of little value predicting yield of steak and roast meat from the carcass. Within groups selected for both conformation and fat thickness, the superior conformation carcasses yielded more ($P < .05$) steak and roast meat in the loin and rib (table 10). When comparing groups I and II (table 10) it should be noted that poor conformation carcasses yielded a slightly greater amount of steak and roast from the chuck. When comparing groups III and IV (those with restricted outside fat) it should be noted that greater amounts of steak and roast meat were obtained totally and in each primal except the rib from those carcasses with more desirable conformation.

Carcasses with superior conformation yielded more ($P < .05$) kilograms and percent of their primal cut yield in the form of total steak and roast meat from the four primals (table 10). Superior conformation carcasses also had more ($P < .05$) steak and roast yield from the loin and

Table 13. Correlation Coefficient Between Carcass Conformation, Fat Thickness and Weight Steak and Roast Meat

	Carcass Conformation	Fat Thickness	Weight Round Steak & Roast	Weight Loin Steak & Roast	Weight Rib Steak & Roast	Weight Chuck Steak & Roast	Weight Total Steak & Roast
Carcass Conformation	1.00						
Fat Thickness	0.26	1.00					
Weight Round Steak and Roast	-0.18	-0.58	1.00				
Weight Loin Steak and Roast	-0.05	-0.43	0.47	1.00			
Weight Rib Steak and Roast	0.16	-0.06	0.24	0.39	1.00		
Weight Chuck Steak and Roast	-0.06	-0.38	0.50	0.09	0.09	1.00	
Weight Total Steak and Roast	-0.11	-0.58	0.58	0.72	0.41	0.51	1.00

Correlation 0.250 are significant ($P < .05$)
Correlation 0.325 are significant ($P < .01$)

Table 14. Correlation Coefficient Between Carcass Conformation, Fat Thickness and Percent Steak and Roast Meat

	Carcass Conformation	Fat Thickness	Percent Round Steak & Roast	Percent Loin Steak & Roast	Percent Rib Steak & Roast	Percent Chuck Steak & Roast	Percent Total Steak & Roast
Carcass Conformation	1.00						
Fat Thickness	0.26	1.00					
Percent Round Steak and Roast	0.15	0.38	1.00				
Percent Loin Steak and Roast	0.03	-0.40	-0.38	1.00			
Percent Rib Steak and Roast	0.23	-0.02	-0.39	0.41	1.00		
Percent Chuck Steak and Roast	0.03	-0.39	0.18	0.27	0.05	1.00	
Percent Total Steak and Roast	-0.11	-0.33	-0.45	0.50	0.16	0.58	1.00

Correlation 0.250 are significant ($P < .05$)
Correlation 0.325 are significant ($P < .01$)

rib. Differences in yield of steak and roast meat from the round and chuck were not significant at the ($P < .05$) level but were still in favor of high conformation carcasses.

When comparing the yield of steak and roast meat between random and restricted fat groups, carcasses with restricted external fat yielded more ($P < .05$) steak and roast meat totally and from all primals except the rib.

Within groups selected both for external fatness and conformation, group IV (high conformation restricted fat) showed an advantage ($P < .05$) in percent yield of loin steak and roast meat (table 15) over all other groups. Weight and percent rib steak and roast meat yield was also highest ($P < .05$) in group IV (6.8 kg. and 4.3%), with group II having the second highest yield (6.3 kg. and 4.0%) being greater ($P < .05$) than group III but not greater than group I. Group III had the lowest percent yield of rib steak and roast yield (3.7 percent) (table 15) of any group.

In comparing total steak and roast meat yield between groups in table 15, no differences ($P < .05$) were noted. However, comparing groups of similar fatness, the higher conformation groups tended to yield more kilograms and percent steak and roast meat with group IV having the greatest amount. This agrees with the findings of Breidenstein (1962) who found no significant relationship between conformation score and yield of retail cuts in steer carcasses of choice and prime conformation. In contrast Martin _et al_. (1966)

Table 15. Selected Group Means for Weight and Percent Primal Cut Steaks and Roast Meat

Primal cuts	Group I[1] kg.	Group II[2] kg.	Group III[3] kg.	Group IV[4] kg.
Round	19.0	19.9	21.5	21.6
Loin	11.9	12.1	12.5	13.4
Rib	5.9[a]	6.3[b]	5.9[a]	6.8[c]
Chuck	17.0	16.6	17.5	17.7
Primal cuts	53.0	54.8	57.3	59.5
Primal cuts	**%**	**%**	**%**	**%**
Round	12.3	12.6	13.5	13.7
Loin	7.9[a]	7.6[a]	7.8[a]	8.6[b]
Rib	3.8[ab]	4.0[b]	3.7[a]	4.3[c]
Chuck	10.5	10.5	11.0	11.3
Primal cuts	34.4	34.7	36.0	37.9

1 Average good or lower conformation, random external fat.
2 Low prime or higher conformation, random external fat.
3 Average good or lower conformation, selected external fat.
4 Low prime or higher conformation, selected external fat.
5 Muscle systems in bovine side of two inches or more in thickness from the round, loin, rib, or chuck.
a,b,c Means in the same row with different superscript letters are significant ($P < .05$) different.

reported that carcasses of choice conformation yielded greater amounts of thick vs thin muscled cuts compared to standard conformation carcasses.

<u>Weight and Percent Primal Cuts Edible Portion</u>

Carcasses with superior conformation yielded a higher ($P < .05$) percent of total primal cut edible portion than did the poorer conformation carcasses (table 16). Weight of edible portion was not significantly greater from the superior conformation carcasses. Low prime or higher conformation carcasses had greater ($P < .05$) weight and percent of edible portion from the rib (table 16). Superior conformation carcasses also showed a non-significant advantage in both weight and percent edible portion from the round and loin, with lower conformation carcasses yielding slightly more from the chuck (table 16).

Comparing the yield of edible portion between random and restricted external fat groups, the restricted group yielded more ($P < .05$) weight and percent edible portion in (2.4 kg. and 1.4%), loin (1.9 kg. and 1.1%), rib (0.5 kg. and 0.2), and chuck (2.9 kg. and 1.6%); therefore, it is obvious that total primal cut edible portion would be greater ($P < .05$) in the group with restricted external fatness (7.8 kg. and 4.3%) (table 15). Outside fatness has a highly significant effect on weight and percent yield of total carcass edible portion (table 17 and 18).

Table 16. Conformation and Fat Thickness Group Means for Weight And Percent Primal Cut Edible Portion[1]

Wholesale cuts	Conformation groups: Average good or lower kg.	Low prime or higher kg.	P kg.	Average good or lower %	Low prime or higher %	P %
Round	24.4	25.0	N.S.	15.5	15.9	N.S.
Loin	15.8	16.3	N.S.	10.1	10.4	N.S.
Rib	8.8	9.4	N.S.	5.6	6.0	<.05
Chuck	32.4	32.0	N.S.	20.7	20.3	<.05
Total edible portion from primal cuts	81.4	82.8	N.S.	51.9	52.6	<.05
Total edible portion from side	101.5	102.1	N.S.	75.5	81.1	<.05

Wholesale cuts	Fat thickness groups: Random external fat kg.	Selected external fat kg.	P kg.	Randon external fat %	Selected external fat %	P %
Round	23.5	25.9	<.05	15.0	16.4	<.05
Loin	15.2	17.1	<.05	9.7	10.8	<.05
Rib	8.8	9.3	<.05	5.7	5.9	<.05
Chuck	30.8	33.7	<.05	19.7	21.3	<.05
Total edible portion from primal cuts	78.2	86.0	<.05	50.1	54.4	<.05
Total edible portion from side	97.2	106.5	N.S.	73.5	85.6	<.05

1 Includes steak and roast meat and trim suitable for ground beef.

Table 17. Analysis of Variance for Weight of Edible Portion from Each Primal Cut and Total Edible Portion

Source of Variance	d.f.	Round edible portion	Loin edible portion	Rib edible portion	Chuck edible portion	Total edible portion
Fat thickness	1	592.97**	347.78**	26.91*	832.69**	5935.68**
Conformation	1	46.40	21.84	39.20**	17.21	180.89
Fat thickness and conformation	1	0.68	7.44	6.73	8.13	2.70
Error	76	28.04	11.06	4.10	30.21	173.79

** (P < .01)
* (P < .05)

Table 18. Analysis of Variance for Percent of Edible Portion from Each Primal Cut and Total Edible Portion

Source of Variance	d.f.	Round edible portion	Loin edible portion	Rib edible portion	Chuck edible portion	Total edible portion
Fat thickness	1	37.56**	23.23**	1.33**	50.22**	
Conformation	1	2.62	1.33	2.77**	2.57	
Fat thickness and conformation	1	1.28	2.95	1.67*	1.07	
Error	76	1.84	0.85	0.31	1.55	

** $(P < .01)$
* $(P < .05)$

Correlation coefficients between carcass conformation, fat thickness and yields of edible portion are given in tables (19 and 20). Fat thickness showed a highly significantly ($P < .01$) negative relationship to weight and percent edible portion from the round, loin, chuck and totally from the four primals (table 19 and 20). Correlation coefficients between conformation and yields of edible portion were non-significant and near zero (table 19 and 20). This simply indicates that when conformation is evaluated without taking external fatness into consideration it is of little value in predicting yield of total edible portion from the carcass.

Within groups selected both for external fatness and conformation, group IV (high conformation restricted fat) showed an advantage ($P < .05$) in percent yield of rib edible portion (table 21). The superior conformation restricted fat group (group IV) out-yielded all other groups in weight and percent edible portion totally from the primals and from all individual primals except the chuck (table 21) where the low conformation restricted fat group (group III) yielded the most.

Weight and Percent Primal Cut External and Internal Fat Trim

Superior conformation carcasses yielded more ($P < .05$) weight and percent of external fat trim from all primals than did the low conformation carcasses (table 22). Superior

Table 19. Correlation Coefficient Between Carcass Conformation, Fat Thickness and Weight of Edible Portion

	Carcass Conformation	Fat Thickness	Weight Round Edible Portion	Weight Loin Edible Portion	Weight Rib Edible Portion	Weight Chuck Edible Portion	Weight Primal Edible Portion	Weight Total Edible Portion
Carcass Conformation	1.00							
Fat Thickness	0.26	1.00						
Weight Round Edible Portion	-0.20	-0.62	1.00					
Weight Loin Edible Portion	-0.04	-0.52	0.65	1.00				
Weight Rib Edible Portion	-0.08	-0.15	0.40	0.46	1.00			
Weight Chuck Edible Portion	-0.10	-0.39	0.61	0.52	0.32	1.00		
Weight Primal Edible Portion	-0.14	-0.57	0.89	0.81	0.57	0.84	1.00	
Weight Total Edible Portion	-0.15	-0.53	0.83	0.77	0.53	0.82	0.95	1.00

Correlation 0.250 are significant ($P<.05$)
Correlation 0.325 are significant ($P<.01$)

Table 20. Correlation Coefficient Between Carcass Conformation, Fat Thickness and Percent of Edible Portion

	Carcass Conformation	Fat Thickness	Percent Round Edible Portion	Percent Loin Edible Portion	Percent Rib Edible Portion	Percent, Chuck Edible Portion	Percent Primal Edible Portion	Percent Total Edible Portion
Carcass Conformation	1.00							
Fat Thickness	0.26	1.00						
Percent Round Edible Portion	-0.49	-0.59	1.00					
Percent Loin Edible Portion	0.04	-0.50	0.49	1.00				
Percent Rib Edible Portion	-0.00	-0.12	0.11	0.41	1.00			
Percent Chuck Edible Portion	-0.01	-0.44	0.25	0.41	0.17	1.00		
Percent Primal Edible Portion	-0.14	-0.57	0.57	0.58	0.34	0.68	1.00	
Percent Total Edible Portion	-0.15	-0.53	0.52	0.53	0.28	0.64	0.95	1.00

Correlation 0.250 are significant $(P < .05)$
Correlation 0.325 are significant $(P < .01)$

Table 21. Selected Group Means for Weight And Percent Primal Cuts Edible Portion[1]

Primal cuts	Group I[2] kg.	Group II[3] kg.	Group III[4] kg.	Group IV[5] kg.
Round	23.1	23.9	25.6	26.2
Loin	15.1	15.2	16.6	17.4
Rib	8.6	9.0	8.9	9.8
Chuck	30.8	30.7	34.0	33.3
Total edible portion primal cut	81.4	78.2	82.8	86.0
Total edible portion from carcass	77.3	97.2	105.8	107.0
Primal cuts	**%**	**%**	**%**	**%**
Round	15.0	15.1	16.1	16.7
Loin	9.8	9.6	10.5	11.1
Rib	5.6[a]	5.7[a]	5.6[a]	6.2[b]
Chuck	20.0	19.4	21.3	21.2
Total edible portion primal cut	51.9	50.1	52.6	54.4
Total edible portion from carcass	77.5[a]	77.6[a]	73.5[a]	85.6[b]

1 Includes steak and roast meat and trim suitable for ground beef.
2 Average good or lower conformation, random external fat.
3 Low prime or higher conformation, random external fat.
4 Average good or lower conformation, selected external fat.
5 Low prime or higher conformation, selected external fat.
a,b Means in the same row with different superscript letters are significantly ($P < .05$) different.

Table 22. Conformation and Fat Thickness Group Means for Weight and Percent Retail Cut External and Internal Fat Trim

Primal cuts fat trim	Conformation groups					
	Average good or lower kg.	Low prime or higher kg.	P kg.	Average good or lower %	Low prime or higher %	P %
Round						
ext. fat trim	1.6	2.7	<.05	1.1	1.7	<.05
int. fat trim	2.0	2.1	N.S.	1.3	1.3	N.S.
Loin						
ext. fat trim	2.2	3.0	<.05	1.4	1.9	<.05
int. fat trim	1.4	1.5	<.05	.9	1.0	<.05
Rib						
ext. fat trim	1.0	1.4	<.05	0.6	0.9	<.05
int. fat trim	0.5	0.8	<.05	0.3	0.5	<.05
Chuck						
ext. fat trim	1.4	1.9	<.05	0.9	1.2	<.05
int. fat trim	3.4	4.1	<.05	2.2	2.6	<.05
Total fat trim from primal cuts						
ext. fat trim	6.2	9.0	<.05	8.6	11.1	<.05
int. fat trim	14.5	15.2	N.S.			

Table 22 (continued)

Primal cuts fat trim	Fat thickness groups					
	Random external fat kg.	Selected external fat kg.	P kg.	Random external fat %	Selected external fat %	P %
Round						
ext. fat trim	2.7	1.7	< .05	1.7	1.1	< .05
int. fat trim	2.1	2.0	N.S.	1.3	1.2	< .05
Loin						
ext. fat trim	3.2	2.0	< .05	2.0	1.3	N.S.
int. fat trim	1.5	1.4	N.S.	1.0	0.9	N.S.
Rib						
ext. fat trim	1.5	0.9	< .05	1.0	0.5	< .05
int. fat trim	0.7	0.5	< .05	0.5	0.3	< .05
Chuck						
ext. fat trim	2.1	1.2	< .05	1.3	0.8	< .05
int. fat trim	4.2	3.3	< .05	2.7	2.1	< .05
Total fat trim from primal cuts						
ext. fat trim	9.4	5.8	< .05	11.5	8.2	< .05
int. fat trim	15.7	14.1	< .05			

conformation also resulted in more ($P < .05$) internal fat trim in all primal cuts except the round (table 22). When comparing total external and internal fat trim from all four primals, high conformation carcasses have more ($P < .05$) external fat trim and slightly but non-significantly more internal fat trim (table 22).

Comparing the yield of fat trim between groups, as expected carcasses with restricted external fat yielded less ($P < .05$) weight of external fat trim from all primals as well as totally (table 22). The restricted fat group also showed less ($P < .05$) internal fat trim (weight and percent) from the primals which normally have considerable amounts of seam fat (rib and chuck) as well as less total internal fat trim (table 22). The round which also usually has considerable seam fat yielded less ($P < .05$) percent fat in carcasses from the restricted fat group (table 22).

Within groups selected both for external fatness and conformation, group II (high conformation randon fat) yielded the greatest ($P < .05$) external fat trim in kilograms and percent from the round and loin (table 23). This group also had the most ($P < .05$) kilograms of internal fat trim from the round and loin (table 23). Group II yielded the greatest ($P < .05$) percentage of total external fat trim with group III (low conformation, restricted fat) showing less ($P < .05$) percentage external fat than any group except group IV (high conformation, restricted fat).

Table 23. Selected Group Means for Weight and Percent Primal Cut External and Internal Fat Trim

Primal cuts fat trim	Group I[1] kg.	Group II[2] kg.	Group III[3] kg.	Group IV[4] kg.
Round				
ext. fat trim	2.0[b]	3.4[c]	1.4[ac]	2.0[ab]
int. fat trim	1.0[a]	2.2[b]	2.0[a]	1.9[a]
Loin				
ext. fat trim	2.4[a]	3.9[b]	1.9[a]	2.1[a]
int. fat trim	1.3[a]	1.7[b]	1.4[ab]	1.5[ab]
Rib				
ext. fat trim	1.2	1.8	.6	.9
int. fat trim	.6	.9	.4	.6
Chuck				
ext. fat trim	1.7	2.5	1.1	1.3
int. fat trim	3.6	4.8	3.2	3.6
Total fat trim from primal cuts				
ext. fat trim	7.3	11.6	5.0	6.4
int. fat trim	15.3	16.1	13.7	14.2

Table 23 (continued)

Primal cuts fat trim	%	%	%	%
Round				
ext. fat trim	1.3^{b}	2.1^{c}	0.9^{a}	1.3^{b}
int. fat trim	1.3	1.4	1.2	1.2
Loin				
ext. fat trim	1.6^{b}	2.4^{c}	1.2	1.4^{ab}
int. fat trim	.8	1.1	.9	.9
Rib				
ext. fat trim	.8	1.1	.4	.6
int. fat trim	.4	.6	.2	.4
Chuck				
ext. fat trim	1.1	1.6	.7	.8
int. fat trim	2.4	3.0	2.0	2.1
Total fat trim from primal cuts ext. fat trim	9.6^{b}	13.4^{c}	7.6^{a}	8.7^{ab}

1 Average good or lower conformation, random external fat.
2 Low prime or higher conformation, random external fat.
3 Average good or lower conformation, selected external fat.
4 Low prime or higher conformation, selected external fat.
a,b,c Means in the same row with different superscript letters are significantly ($P < .05$) different.

When comparing groups, groups III and IV parallel each other with the only significant difference in fat trim between the two groups being in the weight and percent of external fat trim from the round (table 23). These results point out that carcasses in group I, even though they were selected with random fatness, did not have as much fat trim as did the carcasses in group II (also random outside fatness). This would indicate that carcasses with poor conformation do not get as fat externally on the average as do carcasses with superior conformation.

Weight and Percent Bone

Tables 24 and 25 show that conformation has a highly significant effect on the weight and percent bone in each primal cut as well as totally from all primal cuts. Superior conformation carcasses yielded less ($P < .05$) kilograms of bone in the round (0.9 kg.), loin (0.4 kg.), rib (0.4 kg.), chuck (1.3 kg.), and totally from the carcass (7.5 kg.) than did the lower conformation group (table 26). This agrees with the findings of Martin (1966) who found that the most striking advantage of choice conformation carcasses over standard conformation was a higher ratio of total muscle to bone.

Comparing the yield of bone between the random and restricted fat groups, carcasses with random external fat yielded less ($P < .05$) kilograms of bone in the round, rib,

Table 24. Analysis of Variance for Weight of Bone from Each Primal Cut and Totally from All Primal Cuts

Source of Variance	d.f.	Round bone	Loin bone	Rib bone	Chuck bone	Total primal bone
Fat thickness	1	21.53*	3.40	1.92	14.20	135.46*
Conformation	1	87.15**	19.31**	17.67**	174.34**	969.53**
Fat thickness and conformation	1	5.89	1.89	2.89	39.9 **	139.66*
Error	76	3.70	1.05	0.43	3.63	22.48

** $(P<.01)$
* $(P<.05)$

Table 25. Analysis of Variance for Percent of Bone From Each Primal Cut and Totally From All Primal Cuts

Source of Variance	d.f.	Round bone	Loin bone	Rib bone	Chuck bone	Total primal bone
Fat thickness	1	1.20*	0.16	0.08	0.62	6.60*
Conformation	1	7.56**	1.74**	1.53**	14.9**	84.12**
Fat thickness and conformation	1	0.11	0.04	0.11	2.04	5.24
Error	76	0.26	0.07	0.03	0.24	1.39

** ($P < .01$)
* ($P < .05$)

and totally from primal cuts than did the restricted external fat group (table 26). There was also less ($P < .05$) percent bone in total primal cuts and totally from the carcasses in the random external fat group.

Within groups selected both for external fatness and conformation, group III (lower conformation restricted fat) yielded greater ($P < .05$) weight of bone in the rib, chuck, totally from primal cuts, and totally from the carcass than did the other groups (Table 27). Group I (lower conformation random fat) also yielded more ($P < .05$) bone than groups II and IV (higher conformation groups), totally from the carcass, from the primal cuts and individually from the chuck and rib (table 27). The low conformation groups (I and III) also tended to yield more bone from the round and loin than did the high conformation wholesale cuts. This trend follows the findings of Martin (1966) that bone to muscle ratio was greater in the lower conformation carcasses.

Summary

Four groups of 20 steer carcasses each were used in a 2 X 2 factorial design with two conformation levels (average good or poorer vs low prime or better and two fat selection groups (random vs 0.76 to 1.12 cm.)

Results of this study showed that superior conformation carcasses tend to have larger ($P < .05$) longissimus dorsi muscles area. Indications were that carcasses with greater

Table 26. Conformation and Fat Thickness Group Means for Weight and Percent Bone

Primal cut bone	Conformation groups: Average good or lower kg.	Low prime or higher kg.	P kg.	Average good or lower %	Low prime or higher %	P %
Round	6.4	5.5	<.05	4.1	3.5	N.S.
Loin	3.3	2.9	<.05	2.1	1.8	N.S.
Rib	2.6	2.2	<.05	1.7	1.4	N.S.
Chuck	7.1	5.8	<.05	4.5	3.7	N.S.
Total bone primal cuts	19.4	15.3	<.05	12.4	10.3	<.05
Total bone from carcass[1]	41.6	34.1	<.05	11.0	9.2	<.05

Primal cut bone	Fat thickness groups: Random external fat kg.	Selected external fat kg.	P kg.	Random external fat %	Selected external fat %	P %
Round	5.7	6.4	<.05	3.7	3.9	N.S.
Loin	2.9	3.2	N.S.	1.9	2.0	N.S.
Rib	2.3	2.4	<.05	1.5	1.6	N.S.
Chuck	6.3	6.7	N.S.	4.0	4.2	N.S.
Total bone primal cuts	17.3	18.5	<.05	11.1	11.6	<.05
Total bone from carcass[1]	37.0	38.7	N.S.	9.7	10.5	<.05

1 Total carcass bone estimated using flank separable components and length of round as done by Allen (1966).

Table 27. Selected Group Means for Weight and Percent Bone

Primal cut bone	Group I[1] kg.	Group II[2] kg.	Group III[3] kg.	Group IV[4] kg.
Round	6.1	5.4	6.8	5.6
Loin	3.1	2.8	3.4	2.9
Rib	2.4[b]	2.2[a]	2.8[c]	2.2[a]
Chuck	6.6[b]	5.9[a]	7.7[c]	5.7[a]
Total bone from primal cuts	18.2[b]	16.3[a]	20.6[c]	16.3[a]
Total bone from side	39.7[b]	34.4[a]	43.6[c]	33.8[a]
Primal cut bone	**%**	**%**	**%**	**%**
Round	3.9	3.4	4.2	3.6
Loin	2.0	1.8	2.2	1.8
Rib	1.6	1.4	1.7	1.4
Chuck	4.3[b]	3.7[a]	4.8[c]	3.6[a]
Total bone from primal cuts	11.8	10.3	12.9	10.4
Total bone from side	10.7	8.7	11.4	9.6

1 Average good or lower conformation, random external fat.
2 Low prime or higher conformation, randon external fat.
3 Average good or lower conformation, selected external fat.
4 Low prime or higher conformation, selected external fat.
a,b,c Means in the same row with different superscript letters are significantly ($P < .05$) different.

amounts of outside fat within the same conformation constraints tended to have smaller longissimus muscle area than did those with restricted outside fat. This could mean that greater amounts of outside fat can mask size of longissimus muscle and influence conformation score. Low conformation carcasses had greater ($P < .05$) amounts of kidney knob than did high conformation carcasses.

Yield of loin, rib and brisket in both weight and percent were higher ($P < .05$) in superior conformation carcasses. Low conformation carcasses have more ($P < .05$) weight and percent kidney knob and shank and a greater ($P < .05$) percentage chuck than do higher conformation carcasses.

Carcasses with restricted outside fat had greater ($P < .05$) weight of round, loin, and chuck but less plate and flank.

Superior conformation carcasses had more steak and roast yield from the loin and rib as well as total from the four primal cuts. Carcasses with restricted outside fat levels yield greater ($P < .05$) weights and percentages of steak and roast meat totally from the primals as well as individually from all primals except the rib.

Superior conformation carcasses yielded greater ($P < .05$) amounts of edible portion in the rib in both weight and percent as well as totally from the four primals.

Although no difference ($P < .05$) was noted, it is apparent that the higher conformation carcasses out-yielded the poorer conformation carcasses in the edible portion from the round, and loin. Yield from the chuck slightly favors the low conformation group.

Superior conformation carcasses yielded greater ($P < .05$) amounts of external fat trim from all primals than did the low conformation carcasses. Superior conformation carcasses have more ($P < .05$) external fat trim and slightly but non-significantly more internal fat trim from all primals than did the low conformation carcasses.

Superior conformation carcasses yielded less kilograms of bone in the round, loin, rib, chuck and totally from the carcass than did the lower conformation group.

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CHAPTER III

Effect of Conformation on Quantity of Muscle Yield in Bovine

Controversy exists in the literature as to whether animals of widely different body types and breeds are likely to have any major differences in the proportion of their muscle distribution. Butterfield (1963) stated that it is generally believed that what is regarded as good beef conformation produces a relatively high proportion of most valuable meat cuts. Exponents of many beef breeds believe that their breed has the most meat "in the right places". If these claims are sound, we must assume that differences of conformation between breeds are brought about largely by variation in the distribution of muscle, or fat, or both. Conversely, Martin _et al_. (1966) reported that carcasses having choice conformation yielded significantly more steak and roast yield than carcasses with standard conformation.

This study was undertaken to attempt to determine if individual muscles differed in proportion to total carcass muscle in steer carcasses of widely differing shapes. Breidenstein _et al_. (1962) reported that of nine major pork muscles from the pelvic limb, back and thoracic limb, the _supraspinatus_, _semitendinosus_ and _adductor_ muscles differed most between left and right sides but averages were not significantly different. Right sides averaged 0.5 cm. longer and yielded loins weighing 0.5 kg. less than left sides. They suggested that an off center split permitted the side with less skeletal support to stretch more during chilling. Consequently, that side would be longer and would yield a lighter weight wholesale "loin".

Butterfield (1963b) reported, apart from indicating that differences of muscles weight distribution are probably small, studies on yields of meat cuts show limited value in clearly defining what part fat and muscle play in producing differences.

The distribution of muscle weight over the carcass of cattle is the result of response to functional demands by the animal to meet the challenges of its environment as stated by Butterfield (1963b). This vital anatomical response is capable of strongly resisting changes animal breeders would like to force upon it. Efforts to increase the total amount of muscle per animal have been more productive than "attempts to upset intrinsic muscle relationships of this functional locomotor system". Some individual muscle weights reported by Hiner and Hankins (1939), Breidenstein _et al_. (1964) and Topel _et al_. (1965) are summarized in table 28.

Martin _et al_. (1966) working with ten low choice and ten high standard conformation steer carcasses found that standard conformation carcasses produced longer, wider, thinner muscles and muscle systems than choice carcasses;

Table 28. Individual Muscle Weights

	Hiner & Hankins mean	Breidenstein mean	SD	Topel mean	SD
Average line weight, kg.	102.0	100.0		95.5	
Muscle, gm.					
Adductor	171.8	212	28		
Biceps femoris		818	131	764.3	112.4
Psoas major				233.0	43.4
Quadriceps femoris		758	89		
Rectus femoris	238.7			282.9	38.2
Semimembranosus	480.6	653	93	623.4	79.1
Semitendinosus	219.4	313	50		
Longissimus dorsi		1514	235	1282.1	221.2
Supraspinatus		324	38		
Triceps brachii		533	52		

however, the advantages in length and width for the standard carcasses disappeared when muscles thinner than a 2 inch minimum thickness requirements were not included. The most striking advantages of choice conformation were found to be in the ratio of total muscle to bone, and of thick, high value muscle to bone. Thus, among carcasses of approximately the same degree of finish, carcasses grading higher in conformation were superior to the lower grading conformation carcasses in terms of thick meat and total lean.

Richmond and Berg (1972) used 14 sides of boars and gilts and dissected individual muscles. Those muscles representing the expensive carcass cuts were combined into three "expensive muscle groups". They were expressed as percentage of total side muscle in boars, barrows and gilts, respectively with the following results: Ham, 32.5%, 32.5% 33.4%; Ham + Loin, 49.7%, 51.0%, 51.6%; and Ham + Loin + Shoulder, 62.4%, 62.8%, 63.8%. They claimed sex had no significant effect on muscle distribution but slight differences among boars, barrows and gilts were noted. Gilts had a slightly greater proportion of muscle in the proximal hind limb than either barrows or boars, and barrows had a greater proportion of spinal muscles than either boars or gilts. Boars had a slightly greater proportion of muscles in the neck, thorax and fore limb than either barrows or gilts.

Warwick (1958) concluded a review of investigation of the yield of high priced cuts by stating that "it, thus, appears to be quite definite that if hereditary differences in the percent of high-priced cuts do in fact exist, they are not closely related to the factors most of us have been taught to look for in evaluating the external appearance of beef cattle".

Experimental Procedure

Four groups of 20 steer carcasses were selected and used in this study. A summary of specifications and selection criteria is presented in table 2.

Carcasses were selected at packing plants in the area and the left side purchased and brought to the Kansas State University meats lab for fabrication. The average side weight of the four groups varied by 2.2 kg. from 156.0 to 158.2 kg. (table 3). Carcass weight range was restricted so as to avoid differences in cut-out due to carcasses weight.

Muscle Dissection

The following muscles were individually dissected (fat trimmed to 0.75 cm.) from the side during fabrication: psoas major, longissimus dorsi, semitendinosus, biceps femoris, gluteus madeus (biceps from the loin), supraspinatus, and semimembranosus.

These muscles were individually weighed and the majority measured for length at their longest point. Three muscles were measured for circumference with the *psoas major* being measured at a distance of 40% of its length from the posterior end of the muscle. The *semitendinosus* and *supraspinatus* were measured for circumference at 30% of their length from the more medial end of each.

Total carcass muscle was estimated using the separable flank components as predictors according to the method of Allen (1966). The proportion of this estimated total muscle mass made up by each individual muscle was determined by dividing the individual muscle weight by the weight of the estimated total carcass muscle.

Statistical Analysis

The statistical procedures followed are described by Snedecor (1956). A 2 x 2 factorial analysis with 10 carcasses per cell was calculated to determine treatment and interaction effects on muscle yields and measurements. Fisher's least significant difference (LSD) means separation procedure was used to evaluate significance of individual differences among interaction means. Simple correlation coefficients were calculated on a within treatment subclass basis and were pooled to estimate the relationship among most carcass measurements. Least squares analysis of variance (Kemp, 1970) was used to analyze all variables in which there was missing data.

RESULTS AND DISCUSSION

Conformation showed a highly significant ($P < .01$) effect on weight and percent <u>biceps femoris</u> yield from the carcass (table 29). A similar effect ($P < .01$) is noted on the percent yield of the <u>semitendinosus</u> and <u>semimembranosus</u> (table 30). External fat thickness had a highly significant effect on the weight of <u>semitendinosus</u>, <u>semimembranosus</u>, and <u>biceps femoris</u> (table 29).

Carcasses with superior conformation yielded heavier ($P < .05$) <u>semitendinosus</u> and <u>biceps femoris</u> muscles than did carcasses with lower conformation (table 31). Superior conformation carcasses also yielded greater percent ($P < .05$) of <u>semitendinosus</u>, <u>biceps femoris</u>, <u>semimembranosus</u>, and <u>Gluteus medius</u> (biceps from the loin) (table 31). However, low conformation carcasses yielded more ($P < .05$) kilograms of <u>supraspinatus</u> than carcasses with superior conformation (table 31).

Carcasses with restricted fat yielded ($P < .05$) greater weight and percent of <u>semitendinosus</u> and <u>semimembranosus</u> than did the random fat group (table 31). Restricted fat carcasses also had greater ($P < .05$) proportion of <u>supraspinatus</u> than did those with random fat, but the latter had greater proportions of <u>psoas major</u> (table 31).

Within groups selected both for external fat thickness and conformation, group IV (high conformation restricted fat) showed an advantage ($P < .05$) over all other groups in the

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Table 29. Analysis of Variance for the Effect of Conformation and Fat Thickness on the Weight of Individual Muscles of the Total Muscle Mass

ource of ariance	d.f.	Psoas major	Long-issimus dorsi	Semi-tendinosus	Biceps femoris	Quad-riceps	Supra-spinatus	Semi-membran-osus	Gluteus medius (biceps from the loin)
at thickness	1	0.03	8.61**	10.19**	5.20	4.80	1.19**	97.46**	10.51
onformation	1	0.71	8.33**	1.50*	23.54**	1.68	0.59*	7.38	3.36
at thickness nd conformation	1	4.03**	2.21*	1.53*	5.00	4.80	0.01	10.59	1.15
rror	76	0.52	0.66	0.32	3.19	2.04	0.12	4.42	2.78

** (P< .01)
* (P< .05)

Table 30. Analysis of Variance for the Effect of Conformation and Fat Thickness on the Percentage of Individual Muscles of the Total Muscle Mass

Source of variance	d.f.	Psoas major	Longissimus dorsi	Semitendinosus	Biceps femoris	Quadriceps	Supraspinatus	Semimembranosus	Gluteus medius (biceps from the loin)
Fat thickness	1	0.54*	0.58**	0.79**	1.13	0.20	0.01	4.66*	0.10
Conformation	1	0.03	0.50**	1.08**	13.45**	0.04	0.02	7.76**	2.85*
Fat thickness and conformation	1	1.18**	0.47**	0.40**	1.39	1.10	0.00	3.37	0.30
Error	76	0.13	0.05	0.05	0.77	0.39	0.02	1.00	0.70

** $(P < .01)$
* $(P < .05)$

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Table 31. Conformation and Fat Thickness Group Means for Weight and Percent for Muscle Sets

Muscles	Conformation groups Average good or lower kg.	Low prime or higher kg.	P kg.	Average good or lower %	Low prime or higher %	P %
Supraspinatus	1.3	1.2	<.05	1.4	1.4	N.S.
Psoas major	1.6	1.6	N.S.	1.9	1.9	N.S.
Semitendinosus	2.0	2.1	<.05	2.3	2.5	<.05
Biceps femoris (from the round)	5.3	5.8	<.05	6.0	6.8	<.05
Semimembranosus	7.4	7.8	N.S.	8.5	9.1	<.05
Quadriceps (from the round)	4.1	3.9	N.S.	4.6	4.6	N.S.
Longissimus dorsi (from the loin)	4.1	4.4	N.S.	2.6	2.8	N.S.
Gluteus medius (biceps from the loin)	3.5	3.7	N.S.	4.0	4.4	<.05

Muscles	Random external fat kg.	Selected external fat kg.	P kg.	Random external fat %	Selected external fat %	P %
Supraspinatus	1.2	1.3	<.05	1.4	1.4	N.S.
Psoas major	1.6	1.7	N.S.	2.0	1.8	<.05
Semitendinosus	1.9	2.2	<.05	2.3	2.5	<.05
Biceps femoris (from the round)	5.4	5.6	N.S.	6.6	6.3	N.S.
Semimembranosus	7.1	8.1	<.05	8.5	9.0	<.05
Quadriceps (from the round)	3.9	4.1	N.S.	4.7	4.6	N.S.
Longissimus dorsi (from the loin)	4.1	4.4	N.S.	2.6	2.8	N.S.
Gluteus medius (biceps from the loin)	3.5	3.8	N.S.	4.2	4.2	N.S.

yield of semitendinosus in kilogram and percent (table 32). It was interesting to note that no semitendinosus difference existed between groups I and II (low and high conformation random fat groups) (table 32). Group IV (high conformation restricted fat) showed an advantage ($P < .05$) in the weight of psoas major over groups II and III (table 32) but not over group I. Group I had a larger percent ($P < .05$) psoas major muscle than all groups except group IV.

Table 33 shows that superior conformation carcasses have shorter ($P < .05$) muscles that are slightly (but not significantly) larger in circumference. This same table shows that carcasses that have restricted external fat cover have longer ($P < .05$) muscles for all muscles measured except the supraspinatus and semitendinosus where the carcasses with random outside fat had longer muscles. This would indicate that except for these latter two muscles, carcasses with superior conformation and/or limited outside fat had shorter muscles (table 34). Group IV carcasses (superior conformation restricted outside fat) yielded psoas major muscles that were larger ($P < .05$) in circumference as well as being slightly longer (non-significantly). This is in contrast to other muscles which were longer in the poor conformation groups (table 34).

Carcass conformation and fat thickness had a significant ($P < .05$) or highly significant ($P < .01$) effect on muscle length except for no conformation effect on the length of the

Table 32. Selected Group Means for Weight and Percent for Muscle Sets

Muscles	Group I[1] kg.	Group II[2] kg.	Group III[3] kg.	Group IV[4] kg.
Supraspinatus	1.2	1.1	1.3	1.3
Psoas major	1.7[ab]	1.5[c]	1.6[bc]	1.7[a]
Semitendinosus	1.9[a]	1.9[a]	2.1[b]	2.4[c]
Biceps femoris (from the round)	5.1	5.8	5.5	5.8
Semimembranosus	7.1	7.0	7.8	8.4
Quadriceps (from the round)	3.8	3.9	4.3	3.9
Longissimus dorsi (from the loin)	4.0	4.2	4.2	4.6
Gluteus medius (biceps from the loin)	3.4	3.5	3.7	3.9
Muscles	**%**	**%**	**%**	**%**
Supraspinatus	1.4	1.4	1.5	1.4
Psoas major	2.0[a]	1.9[b]	1.7[c]	1.9[ab]
Semitendinosus	2.3[a]	2.3[a]	2.3[a]	2.7[b]
Biceps femoris (from the round)	6.0	7.1	6.0	6.6
Semimembranosus	8.4	8.6	8.5	9.5
Quadriceps (from the round)	4.5	4.8	4.7	4.5
Longissimus dorsi (from the loin)	2.6	2.6	2.6	3.0
Gluteus medius (biceps from the loin)				

1 Average good or lower conformation, random external fat.
2 Low prime or higher conformation, random external fat.
3 Average good or lower conformation, selected external fat.
4 Low prime or higher conformation, selected external fat.
a,b,c Means in the same row with different superscript letters are significant ($P < .05$) different.

Table 33. Conformation and Fat Thickness Group Means for Length and Circumference for Muscle Sets

	Conformation groups					
Muscles	Average good or lower length (cm.)	Low prime or higher length (cm.)	P cm.	Average good or lower circumference cm.	Low prime or higher circumference (cm.)	P cm.
Supraspinatus	33.0	30.2	<.05	25.7	26.0	N.S.
Psoas major	65.0	64.0	N.S.	23.1	23.6	<.05
Semitendinosus	39.1	36.8	<.05	28.4	30.0	<.05
Biceps femoris (from the round)	40.1	37.6	<.05			
Quadriceps (from the round)	21.3	19.8	<.05			
Longissimus dorsi (from the loin)	46.7	42.2	<.05			

	Fat thickness groups					
Muscles	Random external fat length (cm.)	Selected external fat length (cm.)	P cm.	Random external fat circumference (cm.)	Selected external fat circumference (cm.)	P cm.
Supraspinatus	35.6	31.0	<.05	25.6	26.9	<.05
Psoas major	63.0	65.8	<.05	23.1	23.6	<.05
Semitendinosus	41.4	37.6	<.05	29.5	32.8	<.05
Biceps femoris (from the round)	37.3	40.4	<.05			
Quadriceps (from the round)	19.8	21.3	<.05			
Longissimus dorsi (from the loin)	43.4	45.5	<.05			

Table 34. Selected Group Means for Length and Circumference for Muscle Sets

Muscles	Group I[1] length (cm.)	Group II[2] length (cm.)	Group III[3] length (cm.)	Group IV[4] length (cm.)
Supraspinatus	33.0	30.2	35.6	31.0
Psoas major	64.5	61.5	65.3	66.3
Semitendinosus	39.1	36.8	41.4	37.6
Biceps femoris (from the round)	38.1	36.6	42.2	38.6
Quadriceps (from the round)	19.8	19.6	22.9	19.8
Longissimus dorsi (from the loin)	45.5	41.1	48.0	42.9
Muscles	**Circumference (cm.)**	**Circumference (cm.)**	**Circumference (cm.)**	**Circumference (cm.)**
Supraspinatus	25.7	26.0	26.9	26.9
Psoas major	23.1	22.9	22.9	24.4
Semitendinosus	28.4	30.0	29.5	32.8
Biceps femoris (from the round)				
Quadriceps (from the round)				
Longissimus dorsi (from the loin)				

1 Average good or lower conformation, random external fat.
2 Low prime or higher conformation, random external fat.
3 Average good or lower conformation, selected external fat.
4 Low prime or higher conformation, selected external fat.

psoas major (table 35). These findings agree with those of Martin et al. (1966) who found that poorer conformation carcasses had longer, thinner muscles.

Correlation coefficient between conformation, fat thickness and weight, length and circumference of various muscle systems are given in table 36. Fat thickness showed a highly significantly (P .01) negative relationship in all muscle systems except for the longissimus dorsi weight and the semitendinosus length. The semitendinosus length shows a significantly (P .05) negative relationship. A very low (-.14) non-significant negative relationship is shown in the longissimus dorsi weight. Correlation coefficients between conformation and the various muscle systems shows a non-significant negative relationship except for the supra-spinatus weight (-.27), length (-.48); Quadriceps weight (-.32), length (-.22) and longissimus dorsi length (-.44).

Summary

Four groups of 20 steer carcasses each were used in a 2 x 2 factorial design with two conformation levels (average good or poorer vs low prime or better) and two fat selection groups (Random vs 0.76 to 1.12 cm.). The following individual muscles were separated from the left side of each carcass, weighed and measured for length and circumference: biceps femoris (from round), Quadriceps (from round), Longissimus (from loin), psoas major and semitendinosus. Total carcass muscle mass was estimated using the flank separable components as predictors according to the method of Allen (1966). Each individual muscle percent of "estimated total carcass muscle mass" was calculated to attempt to estimate differences existed in proportions of muscles between carcasses of widely different shapes. Superior conformation increased ($P < .01$) percent of semitendinosus, semimembranosus and round biceps femoris by 0.2, 0.6 and 0.8% (of estimated total carcass muscle mass). Muscles from carcasses with poorer conformation are longer ($P < .05$) and tend to be smaller around in circumference except for the psoas major which was found to be longer (non-significantly) in group IV carcasses (superior conformation-restricted outside fat).

Table 35. Analysis of Variance for the Effect of Length of Conformation and Fat Thickness on the Length of Individual Muscles of the Total Muscle Mass

Source of variance	d.f.	Psoas major	Longissimus dorsi	Semitendinosus	Biceps femoris	Quadriceps	Supraspinatus
Fat thickness	1	23.87*	13.86**	7.81**	26.80**	8.13*	8.84**
Conformation	1	2.70	70.12**	28.56**	20.30*	7.87*	42.63**
Fat thickness and conformation	1	12.40	0.63	1.74	3.24	6.00	2.66
Error	76	4.71	1.21	0.75	2.94	1.76	0.98

** $(P < .01)$
* $(P < .05)$

Table 36. Correlation Coefficient Between Carcass Conformation, Fat Thickness, Weight, Length and Circumference of Muscle Systems

	Carcass Confor-mation	Fat Thick-mess
Supraspinatus, weight	-.27	-.54
Supraspinatus, length	-.48	-.56
Supraspinatus, circumference	-.11	-.49
Psoas major, weight	-.12	-.36
Psoas major, length	-.18	-.32
Psoas major, circumference	0.06	-.36
Semitendinosus, weight	0.01	-.54
Semitendinosus, length	-.17	-.26
Semitendinosus, circumference	0.13	-.37
Biceps femoris, weight	-.04	-.56
Biceps femoris, length	-.10	-.31
Quadriceps, weight	-.32	-.42
Quadriceps, length	-.22	-.54
Longissimus dorsi, weight	-.05	-.14
Longissimus dorsi, length	-.44	-.35
Longissimus dorsi, circumference	-.18	-.32

Correlation 0.250 are significant $(P < .05)$
Correlation 0.325 are significant $(P < .01)$

Table 37. Analysis of Variance for the Effect of Conformation and Fat Thickness on the Circumference of Individual Muscles of the Total Muscle Mass

Source of variance	d.f.	Psoas major	Semitendinosus	Supraspinatus
Fat thickness	1	1.28*	12.17**	3.66**
Conformation	1	1.28*	18.62**	0.06
Fat thickness and conformation	1	1.95*	1.98	0.00
Error	76	0.32	0.59	0.34

** $(P < .01)$
* $(P < .05)$

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EFFECT OF CONFORMATION ON BOVINE MUSCLE YIELD

by

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Four groups of 20 steer carcasses each were used in a 2 x 2 factorial design with two conformation levels (average good or poorer *vs* low prime or better) and two fat selection groups (Random *vs* 0.76 to 1.12 cm.).

While four groups were selected, within these four were two conformation groups (low conformation and high conformation). Group I and II were selected with external fat thickness at random, whereas in Groups III and IV the outside fat was restricted between 0.5 and 1.0 cm.

The left side from all carcasses was cut into boneless, closely trimmed edible portions. Weight of steak and roast meat (muscles and muscle systems 5 cm. or thicker) from the primal cuts was determined. Ground beef was made with trim from all cuts and fat content was standardized as near 25 percent as possible.

The following muscles were individually dissected from the left side during fabrication: *psoas major*, *longissimus dorsi*, *semitendinosus*, *biceps femoris*, *supraspinatus* and *semimembranosus*. These muscles were individually weighed and the majority measured for length at their longest point. Three muscles were measured for circumference: the *psoas major*, *semitendinosus*, and *supraspinatus*.

Total carcass lean was estimated using the flank separable components as predictors. Each individual muscles percent of the estimated total muscle mass was determined to attempt to estimate if there were differences in the proportions of muscles between carcasses of widely different shapes.

Superior conformation carcasses tend to have larger ($P < .05$) longissimus dorsi muscles. Indications were that carcasses with greater amounts of outside fat within the same conformation constraints tended to have smaller longissimus muscle area than did those with restricted outside fat. This could mean that greater amounts of outside fat could mask the size of the longissimus muscle and influence conformation score. Low conformation carcasses had greater ($P < .05$) amounts of kidney knob than did high conformation carcasses.

Yield of loin, rib and brisket in both weight and percent were higher ($P < .05$) in superior conformation carcasses. Low conformation carcasses have more ($P < .05$) weight and percent kidney knob and shank and a greater ($P < .05$) percentage chuck than do higher conformation carcasses.

Carcasses with restricted outside fat had greater ($P < .05$) weight of round, loin, and chuck but less plate and flank.

Superior conformation carcasses had more steak and roast yield from the loin and rib as well as totally from the four primal cuts. Carcasses with restricted outside fat levels yielded greater ($P < .05$) weights and percentages of steak and roast meat totally from the primals as well as individually from all primals except the rib.

Superior conformation carcasses yielded greater ($P < .05$) amounts of edible portion in the rib in both weight and percent as well as totally from the four primals.

Superior conformation carcasses yielded greater ($P < .05$) amounts of external fat trim from all primals than did the low conformation carcasses. Superior conformation carcasses yielded less kilograms of bone in the round, loin, rib, chuck and totally from the carcass than did the lower conformation group. Superior conformation had a highly effect ($P < .01$) on percent of semitendinosus, semimembranosus and biceps femoris (from round) with these muscles making up respectively 0.2, 0.6 and 0.8 percent more of the estimated total muscle mass. Muscles from carcasses with poorer conformation are longer ($P < .05$) and tend to be smaller around in circumference except for the psoas major.