EFFECT OF BEEF CARCASS CONFORMATION ON THICK AND THIN MEAT YIELDS

By

EVERETT LAWTON MARTIN

Bachelor of Science
Oklahoma State University
Stillwater, Oklahoma
1963

Submitted to the faculty of the Graduate School of
the Oklahoma State University
in partial fulfillment of the requirement
for the degree of
MASTER OF SCIENCE
May, 1965

EFFECTS OF BEEF CARCASS CONFORMATION ON

THICK AND THIN MEAT YIELDS

Thesis Approved:

Lowell E. Walters
Thesis Adviser

R. L. Henrickson

J. A. Boyer
Dean of the Graduate School

ACKNOWLEDGMENT

The author wishes to express his appreciation to Dr. Lowell Walters, Professor of Animal Science, for his assistance and guidance during the course of this study and in the preparation of this thesis. The suggestions and recommendations of Dr. J. V. Whiteman, Professor of Animal Science, concerning the analyses of data and his assistance in improving the manuscript were also greatly appreciated.

Further appreciation is extended to Dr. R. L. Henrickson and Dr. J. J. Guenther of the Animal Science Department for their helpful suggestions and constructive criticisms during the preparation of this manuscript.

In addition, the author thanks Mr. Jim Lacey and Mr. Forest Little of the Oklahoma State University Meat Laboratory for their help in securing and processing the carcasses for this study.

The writer also wishes to express his appreciation to his wife, Gloria, and son, Mark, for their interest and encouragement throughout this course of study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

INTRODUCTION

Beef carcass conformation, as defined in the present federal beef grading standards, has been shown to be confounded with both external and internal fat deposits. Muscling also exerts an effect on carcass conformation. However, only limited data is available concerning the effects of muscling on carcass conformation grade. It has been shown that fat has a more definite influence on carcass cut-out value than does muscling. This suggests that carcass conformation, as described by the U.S.D.A. grading standards, may be relatively unreliable as an estimate of muscling.

The influence of bone on carcass conformation and subsequently upon meat yields has not fully been explored. Several research workers have shown a positive relationship between percentage carcass bone and retail yield. This positive relationship may be due to a relatively constant ratio of lean to bone in the carcass.

The "ideal beef carcass" has often been described as being blocky, compact, straight-sided, smooth and yielding a high percentage of the higher value wholesale cuts (rib, loin and round). Research to date has failed to demonstrate a significant positive association between desirable conformation, as described above, and the yield of separable carcass lean. More detailed information is needed that will more fully establish the relationships of the three major tissues (lean, fat and bone) of the beef carcass to appraisals of carcass conformation.

Present trends in beef cattle breeding and feeding point up the need for more knowledge relative to the importance of certain quantitative characteristics of the carcass as they relate to the yields of saleable "high value" versus "low value" cuts.

This study is concerned with a new concept in beef carcass evaluation wherein a differentiation is made between "high value" steak and roast meat, termed "thick meat" and the lower value trimmings and thin muscles, called "thin meat".

The need for more information concerning some of the relationships between carcass conformation or shape and the yields of high value "thick meat" and the lower value "thin meat" provides the basis for this study.

REVIEW OF LITERATURE

Research dealing with the influence of beef carcass conformation or type on meat yields is limited. Much of the literature available to date fails to show a strong relation between these characteristics.

It has long been the opinion of most animal breeders and researchers that superior conformation in beef cattle is associated with higher retail yields. Historically, in this connection, breeders as well as meats researchers have generally assumed that the thickness in the loin, rib and chuck along with a bulging round, which is associated with desirable conformation, was due largely to increased muscle development. However, more recently, external fat covering and fat deposits between muscles have been shown to influence appreciably visual carcass conformation appraisals. Many researchers believe that appraisal for conformation, within itself, does not adequately evaluate the relative proportions of fat, lean and bone in the beef carcass.

The following review of literature is concerned with: (1) carcass components (lean, fat and bone) and some of their relationships and (2) some of the relationships between carcass conformation (type); U.S.D.A. grades; wholesale cut yields and lean, fat and bone in the beef carcass.

Carcass Components and Some of Their Relationships

From beef carcass evaluation research, fat has been shown to be the largest single variable of the three major carcass components (fat, lean and bone). Lean and bone, on the other hand, have been found to be relatively constant. As early as (1860) Laws and Gilbert, as reported by Hedrick et al. (1963), indicated that the ratio of lean to fat varied within animal species and with age. Both percentage mineral matter and nitrogenous substances in the carcass were found to decrease as the animal matured. However, percentage fat increased at an accelerated rate with age so as to compensate for the decrease in other solid matter. Moulton (1933) reported that the chemical composition of the fat free animal body is practically constant in normal mature animals and concluded that fat is the most significant variable in studies dealing with body composition. Similarly, Callow (1949), in a study involving cattle, sheep and swine, concluded that the major changes in the anatomy of carcasses from birth to maturity and in the chemical composition of their tissues depends largely on the level of fattness of the carcass. Of the three species studied swine showed the widest variation in percentage fat.

Branaman et al. (1936) demonstrated that, within limits, as an animal fattens dressing percentage, carcass grade and percentage fat in the carcass increase and the percentages of lean and bone decrease. Kidwell and McCormick (1956) reported that at a given weight or age, animals of large mature size gain more rapidly on less feed than animals of smaller mature size. Carcasses of larger animals contain a higher proportion of bone and muscle and a lower proportion of fat.

Growth patterns have been studied by many workers. Hammond (1933) found that body growth occurs in three over-lapping phases. Maximum bone growth was found to precede that of muscle and muscle in turn preceded that of fat deposition. McMeekan (1940) reported that tissues which develop early (bone and muscle) are able to compete at lower levels of nutrition more efficiently than fat which develops later. In this connection, Callow (1949) found that a rapid rate of fattening, in beef cattle, led to a specified level of carcass fattness (separable fatty tissue) being reached at a lighter carcass weight in constrast to slower rates of fattening which produce heavier carcasses with the same specified level of fattness. The author concluded that with high rates of fattening, the muscular tissue does not develop as rapidly as it should and results in a carcass that is too fat for its weight.

An investigation was conducted by Callow (1948) to study the changes which take place in meat animal carcasses during growth and fattening. Carcasses from 124 meat animals were used, including 29 cattle representing 8 British breeds, 55 sheep representing 8 British breeds and 1 Icelandic breed and 40 pigs representing 2 breeds. There was a wide variation in ages within any one group. All carcasses were completely disected into muscle, fat, bone and tendon. Changes in percentages of lean, fat and bone were similar for all three species. The ratio of lean to bone was observed to rise as the carcass became fatter. He concluded that this is to be expected because during fattening, muscular tissue grows more rapidly than bone. In carcasses containing 10 percent fatty tissue he observed nearly three times as much muscle as bone and in carcasses containing 20 percent fatty tissue there was nearly four times as much muscle as bone. In extremely fat carcasses (40 percent fatty tissue) there was nearly five times as much fat as bone. The author suggested, that since individual animals have considerably higher or lower ratios of lean to bone than the average 10, 20 and 40 percent carcass fatty tissue, the proportion of muscle to bone can be influenced appreciably by factors other than general level of fattness.

Malkus (1964) found that as age in Hereford heifers advanced from 9 to 18 months that the rate of fat deposition in the different wholesale cuts was the primary factor influencing changes in carcass composition. It was pointed out that the rapid development of fat, as age progressed, decreased the proportion of lean and bone in the carcass.

Several workers have studied bone-muscle relationships of meat animals. Early workers, Hammond (1921); McMeekan (1940, 1942); and Palsson (1939) have completely separated large numbers of animals into muscle, bone and fat. Generally, these workers agree that a strong relationship exists between bone weight and muscle weight. This suggests that the ratio of lean to bone may be relatively constant. McMeekan (1956) reported that, "the weight of muscle can be determined to within one percent if the weights of the cannon bones are known."

Orme et al. (1959) found that the weight-length ratio, width and thickness of the fore and hind cannon bones of beef were highly related to the estimated weight of carcass lean, accounting for 32-58 percent of the variation. The length of the fore and hind cannon bones were found to be directly and significantly related to the percentage primal cuts, r = 0.37 and 0.35 respectively.

Orts and King (1959) reported that simple correlation coefficients indicate that cannon bone weight and weight-length ratios are highly related to wholesale cut weights and rib-eye area in beef carcasses, r = 0.87, 0.88, 0.80 and 0.80 respectively. However, when chilled carcass weight was held constant, by using a partial correlation coefficient analysis, all significance was lost between cannon bone characteristics, weights of wholesale cuts and rib-eye area.

Bone has been shown by numerous workers to be associated to some extent with retail yields. An increase in bone in beef carcasses has been shown to be associated with a small increase in retail meat yield (Orme et al. 1959; Cole et al. 1960; Wythe et al. 1961; Brungardt and Bray 1963).

Callow (1961) reported that the ratio of the weight of muscular tissue to the weight of bone in a carcass is a useful estimate of carcass composition.

Wythe (1961), working with yearling steers, obtained high positive correlations which indicate that bones of an animal develop proportionately in length and width and that an association exists between bone thickness and muscling. The correlation between trimmed tibia weight and weight of the loin, rib, round and rump was 0.74. Correlations of 0.78 and 0.80 respectively were obtained between trimmed tibia weight and weight of "retail trimmed" chuck, rib and loin and "retail trimmed" boneless cushion round and rump.

More detailed work is needed to more fully establish the relationships that may exist between bone and other carcass components. Much research to date on beef carcass evaluation has used total separable lean as the end point for appraisal of meatiness and for the most part no attempts have been made to study bone in relation to "high priced, high value cuts". There may be strong relationships between carcass bone, conformation, yields of "high value cuts" and carcass quality which have hitherto been undisclosed.

Some Relationships Between Beef Carcass Conformation (Type), U.S.D.A. Grades and Wholesale Cut Yields

Much controversy exists concerning the importance of conformation in beef carcasses. Most researchers agree that evaluation for conformation is confounded, at least to some extent, by fat.

Ziegler (1958) has defined conformation as follows: "conformation includes the general build, form, shape or outline of the carcass, side or cut. Its chief significance in grading is the close relationship that exists between conformation and the relative percentage of each major wholesale cut in the carcass, as well as, the proportion of edible meat to bone."

Murphy et al. (1960) reported that measures of "finish" were four and a half times as important as conformation scores in predicting yields of closely trimmed, "mostly bone-in retail cuts" of beef from the four major wholesale cuts. Zinn et al. (1963), working with 100 steers and 100 heifers, reported that percentage fat trim is more than twice as important in predicting percentage boneless primal cuts as is percentage bone.

From work involving 96 beef carcasses Zinn et al. (1961) found the correlation coefficient between conformation scores and fattness to be 0.50. Percentage trimmable fat was positively correlated with conformation grade, $r = 0.69$.

Breidenstein (1962) found little association between conformation and yield of retail cuts in good and choice steer carcasses. However, he established that an increase of one-third of a grade in conformation in heifers was associated with an increase of 0.34 percent in retail yield.

It has been generally assumed that variations existing in beef carcass conformation were associated with the ratio of lean to bone in the carcass and also to the proportion of preferred to less preferred cuts. Murphy (1960) developed an equation for predicting the yield of retail cuts in beef carcasses: Percent boneless retail cuts from the round, loin, rib and chuck = 51.34 - (5.78 x single fat thickness measurement over the rib eye, inches) - (0.462 x percent kidney fat) + (0.740 x area of rib eye, square inches) - (0.0093 x carcass weight, pounds). In general, percentage boneless retail cut yield consisted of the boneless round, loin, rib and chuck, trimmed of external fat covering in excess of one-half inch, and divided into conventional retail cuts (i.e. boneless rump, strip loin, boneless blade chuck, etc.) Utilizing subjective evaluations for exterior and kidney fat, a simple correlation coefficient of 0.92 between the estimated and actual yields of boneless retail cuts was obtained. It was also found that considerations of a conformation score, in addition to measures of external, kidney and pelvic fats, carcass weight and area of rib eye, did not appreciably increase the accuracy of predicting retail yields.

Tyler <u>et al</u>. (1964) made a direct comparison of the cutability and palatability of two groups of carcasses having approximately the same yield grade (dual grade) and the same quality grade but differing substantially in conformation grades. Two groups of 40 steer carcasses each were selected to be as nearly the same quality grade, yield grade and weight as possible. The average combined yields of major retail cuts of 49.6 percent for the high conformation group and 49.7 percent for the low conformation group were almost identical. The estimated yields of major boneless cuts for the high and low conformation groups, based on the yield grade prediction equation (Murphy 1960), were 49.2 and 49.4 percent for the high and low conformation groups respectively. These estimates compared very favorable to the actual yields of 49.6 and 49.7 percent. Fat and bone proved to be the major variables. The higher conformation group had 3.6 percent more fat trim than the lower conformation group. However, this difference in fat was offset by a lower percentage bone. The higher conformation carcasses had only 13.5 percent bone while the lower conformation carcasses had 16.4 percent bone. In this study the higher conformation carcasses had an average ratio of trimmed boneless meat to bone of 5.0 to 1.0. The ratio for the lower conformation carcasses was 4.1 to 1.0. Taste panel scores for the two groups did not reflect any significant palatability differences. Likewise, the Warner-Bratzler shear test also indicated no differences in tenderness between the two groups. The principle conclusion reached was that differences in conformation, among carcasses of the same yield grade, do not result in differences in yields of boneless, closely trimmed retail cuts.

Kemp et al. (1954) reported that U.S.D.A. Choice and Good carcasses differed widely in percentage fat as determined by physical separation of the wholesale rib. Choice carcasses averaged 34.6 percent fat whereas good grade carcasses averaged only 28.8 percent fat.

Similarly, Kidwell et al. (1959) found carcass grade to be largely a function of percentage fat in the carcass. Higher grading carcasses yielded more fat, less bone and muscle and higher percentages of loin, rib and plate than lower grading carcasses. These workers found the percentage of round and chuck to be inversely proportional to carcass grade.

Kropf and Graf (1959) studied the effect of carcass grade, weight and sex classification upon boneless beef yield. Carcasses for this study were selected to fit the mid-point of either the choice, good or commercial (and standard) grade. Cutting data were obtained from carcass groups representing the aforementioned grades in the steer, heifer and cow classifications and 400-500, 600-700 and 800-900 pound carcass weight groups. Approximately 20 carcasses were processed in each experimental group. Boneless beef yield was significantly altered by grade. The highest yield, 66.07 percent, was found in the standard grade and the lowest in the choice grade, 62.93 percent. Fat percentages were also related to grade; higher grades had the most fat and lower grades the least (standard 14.85 percent, good 17.76 percent and choice 20.71 percent). Bone weight, calculated as a percentage of carcass weight, was observed to vary with carcass grade (standard 17.05 percent, good 15.71 percent and choice 14.37 percent). In all cases, less bone was found in higher grades. Boneless beef yield to bone ratios of 4.37, 4.10 and 3.87 were calculated, respectively, for the choice, good and standard grades. "Dry heat steak" yield was unaffected by grade, but there was a greater yield of "dry roast" and "moist heat steak" in the standard and good grades as compared to choice. However, there was a higher percentage of "moist heat roast" in higher grades. In general, boneless beef yield and percentage of bone decreased and fat increased as grade increased from standard to choice. Boneless beef to bone ratio also increased in the higher grades primarily since bone decreased markedly in the higher grades. The authors concluded that the increased boneless beef yield in lower grades cannot be attributed to a higher total yield of "moist and dry heat steak and roast".

Goll et al. (1961a) conducted a study involving 90 steer carcasses ranging in carcass grade from standard to choice and 430 to 670 pounds in weight. Carcasses grading standard, good and choice differed significantly in the average yield of round, loin, rib and chuck. Standard grade carcasses had the highest percentage yield of round, loin, rib and chuck (77 percent) and the choice grade carcasses the lowest (75.2 percent). These workers concluded that "finish" exerts more influence on yields of wholesale cuts than does conformation.

Several workers have reported studies involving different "types" of cattle. Willey et al. (1951) studied relationships between "comprest" and "regular" type Hereford steer carcasses. Percentages of fat, lean and bone in the carcass were determined by the procedure suggested by Hankins and Howe (1946). The percentages of separable fat, lean and bone were not significantly different in carcasses from the two types. The percentage of market weight composed of untrimmed hide, untrimmed head and shanks was greater for the "comprest" type steers. The percentage fore-shank was the only wholesale cut that was significantly different, being greater for the "regular" type. This is in agreement with Stonaker et al. (1952) who concluded that there were no significant differences between "comprest" and "conventional" type Hereford steers with respect to efficiency of gain, days on feed, slaughter age or percentage lean, fat and bone, as determined by the 9-10-11 rib cut separation. The "conventional" type steers dressed, on the average, one percent higher than the "comprest" steers.

Knox (1957) reported that breeding for short legs and short bodies limited the size of cattle. He stated that when carried to the extreme, "small cattle will result". Type (comprest or conventional Hereford steers) did not effect efficiency of energy conversion either in the feed lot or on the range. The only advantage established for compact type was the ability to fatten at lighter weights.

An investigation was conducted by Butler (1957) in an effort to identify the type or types of cattle which show a definite increase in carcass value attributable to a higher yield of preferred cuts. Test steers showed wide variation in conformation (59 Herefords, 90 first cross Hereford x Brahman and 51, 1/4-3/4, Hereford x Brahman crossbreds). The Hereford steers were of a much more desirable conformation by visual estimates. After adjustments for differences in carcass weight were made, the Herefords averaged three centimeters less in body length and six centimeters less in length of hind leg than the first cross and crossbred Hereford-Brahman steers. The carcass cut-out data were very similar for all three groups of steers. The longer carcasses had a slightly higher percentage of hindquarter and round (rump on). The shorter carcasses had a slight advantage in percentage of full loin and chuck. Rather fat carcasses cut-out at a distinct disadvantage and a very poorly shaped carcass with almost no fat showed average cut-out. Fat seemed to be the major cause of variability in cutting yields. Lean and bone were observed to develop proportionately over a relatively wide range of carcass shapes. The authors' principle conclusion was that the beef cattle breeder has considerable latitude in conformation from which to select without encountering great changes in the proportion of wholesale cuts from carcasses.

Branaman et al. (1962) conducted a study involving comparisons of the cutability of beef and dairy type cattle fattened under similar conditions. The beef type cattle were found to have a higher dressing percentage and carcass grade than the dairy type cattle. There were no appreciable differences in percentage of high priced wholesale cuts or total trimmed retail steak. Furthermore, the difference in percentage separable lean in the carcasses between breed types was negligible. These workers stated that there was little advantage for beef type from the standpoint of carcass cut-out value.

Cahill et al. (1959) evaluated the carcasses of 30 Hereford steers and heifers sired by three "long bodied" and three "short bodied" bulls. Significant differences were found in the weight of "edible portion" (included muscle and a maximum of 3/8 inch fat on any exposed surface) from the carcasses of steers sired by the two different types of bulls. These workers reported a high correlation of 0.925 between weight of femur and weight of "edible portion" of the carcasses sired by the "short bodied" bulls. Weights of other long bones were also positively correlated with "edible portion". However, there were only small differences between sire groups when adjustments were made for weight variation.

King et al. (1959) proposed the "retail trim" as a more accurate measure of beef carcass value. This study involved 100 steer carcasses ranging in weight from 204 to 745 pounds and carcass grade ranged from standard to choice. These workers found little or no difference in percentage of wholesale cuts, by the cutting method recommended by Wellington (1953). However, when the wholesale cuts were given a "retail trim" (removal of exterior fat in excess of $\frac{1}{4}$ inch) highly significant differences in percentage wholesale cuts were observed.

A four year study involving 130 animals representing British, Zebu and dairy cattle was reported by Cole et al. (1964). The British breeds were found to have the lowest percentage separable muscle, but the highest percentage separable fat, ether extract, flank and brisket. The long-shanked, long bodied, angular Holstein carcasses produced the highest percentage separable muscle, separable bone, round, and fore-shank, as well as, the highest percentage separable muscle and bone within all except two wholesale cuts, the chuck and plate. With the exception of the fore-shank, the Holsteins were lowest of all breeds in percentage separable fat.

Goll et al. (1961b), working with 90 steers, 30 each from the standard, good and choice grades, found carcass weight to be more closely related to carcass measurements (i.e. length of body, length of hind leg and length of loin measurement) than carcass grade. Carcass grade was found to be more closely correlated with the yields of wholesale cuts than carcass weight. The yields of round and chuck were negatively related to grade, whereas the yields of rib and loin were positively related. Correlations with yield of thick cuts (sum of yields of round, loin, rib and chuck) revealed that the wider, thicker, deeper carcasses, as determined by measurements, yielded a higher percentage of "thick cuts". Ramsey et al. (1962), working with 133 steers representing 8 breeds, studied the relationship between U.S.D.A. beef carcass yield grades. They reported that carcass grade and yield grade were negatively associated with separable lean and bone, but positively associated with fat. Fat was found to have a more definite relationship to percentage separable lean than rib-eye area. Neither U.S.D.A. carcass grade nor yield grade was superior to a single fat thickness measurement over the rib-eye as an estimator of percentage separable lean and fat.

Cole et al. (1962) found length of carcass to be negatively associated with external fat thickness and positively associated with pounds of lean. As carcass grade increased from utility to prime, fat thickness increased and carcass length decreased.

EXPERIMENTAL PROCEDURE

I. Materials

Ten pairs of high standard and low choice conformation steer carcasses were purchased during the spring of 1964, from a meat packing company in Oklahoma City, for this study. All carcasses were selected by the same company representative. In addition to conformational differences, each pair of carcasses was selected to be similar in terms of rib eye area, fat thickness at the twelfth rib, maturity group and estimated percentage kidney, pelvic and heart fats. Marbling scores were also selected to be similar within each pair. No information was available as to the source, breeding, feeding or management practices associated with the production of these carcasses.

Upon arrival at the Oklahoma State University Meat Laboratory, the quartered carcasses were stored in a 34-36 degree Fahrenheit cooler, with approximately 70 percent humidity, for one week prior to cutting. A detailed description of the paired carcasses used appears in the appendix, Table VII.

II. Methods

This study involved a new concept in beef carcass appraisal wherein muscles were classified as either thick or thin meats. In general, thick meats consisted of muscles and/or muscle systems that were considered suitable for steak and/or roast. The remaining muscles (lean tissues) were classified as thin meats. More specifically, the thick muscles of the hind-quarter included closely trimmed, boneless muscles and/or muscle systems that were two inches or more in thickness. They were as follows: strip loin, tenderloin, top-butt, knuckle, top round, bottom round and eye of the round. Fore-quarter thick meats included closely trimmed, boneless muscles and/or muscle systems (free of excessive seam fat) that were three inches or more in thickness. They were classified as chuck and rib roasts. Thin meats included all the lean tissues that did not meet the requirements set up for thick meats.

Muscles and/or muscle systems were trimmed to the specified thickness requirements using a modified swine back-fat probe as a measure of muscle thickness. One end of the probe was sharpened to allow easier penetration into the muscles.

Weights and Measurements

Weights and measurements were taken on the hind-quarter muscles and muscle systems both before and after trimming to the minimum thickness requirements for thick and thin meats. A summary of the measurements taken appears in Table I. Weights of fore-quarter roast were obtained only after they had been trimmed to minimum thickness requirements because of the inability to separate the cervical vertebrae from the chuck at a consistant point. It should be pointed out that this inconsistant separation had little effect on thick meat weight since the roasts required further trimming to meet the requirements for thick meat.

Rib eye area, average fat thickness at the twelfth rib and weight of the internal fats were recorded. Rib eye area and fat thickness were obtained only on the right side of each carcass. Length was recorded for the right femur and tibia of each carcass.

TABLE I

SUMMARY OF MUSCLE MEASUREMENTS TAKEN
ON THE HIND-QUARTER

	Maximum Length[a]	Maximum Width[a]	Maximum Depth
Tenderloin	X		
Strip loin	X		X[b]
Top-butt			X
Knuckle			X
Top Round	X	X	X
Bottom-round	X	X	X
Eye of round	X		

[a]Length and width measurements were recorded to the nearest $\frac{1}{4}$ inch both before and after trimming to minimum thickness requirements.
[b]Depth was recorded at the posterior and anterior ends.

Femur length was measured, with the aid of a caliper, to the nearest one-tenth inch from the most proximal point of the head of the femur to the most distal point of the medial condyle. The tibia was measured in the same manner, from the notch between the medial and lateral condyle of the proximal end to the center of the intermediate ridge at the distal end.

Cutting procedure

At the time of cutting, the fore and hind quarters were placed on a cutting table, "muscle" side down. The internal fats, including the pelvic, kidney and heart fats were removed. Fat in the pelvic region was removed exposing the sacroiliac legaments and the kidney fat was removed so as to fully expose the posas major. "Streamlined carcass weight" refers to the weight of the carcass after the internal fats had been removed.

The streamlined fore and hind quarters were then separated into muscles and muscle systems, fat and bone. After boning, the muscles and muscle systems were placed in a cooler (34-36 degree Fahrenheit) for 12-16 hours. At the end of this period, the muscles and muscle systems were weighed, measured and separated into the thick and thin cuts previously described. The trimmed cuts were then weighed and measured.

A resume of the cutting procedure follows:

HIND-QUARTER

Flank

With the hind-quarter on the cutting table "muscle" side down, the flank was removed by cutting beneath the cod fat, following the natural seam in such a manner as to expose the ventral surface of the tensor fasciae latae, to a point one inch below the ventral edge of the longissimus dorsi, at the thirteenth rib. The flank was then separated into lean, fat and bone. All of the lean in the flank was classified as thin meat.

Knuckle

The knuckle (A, Figure 1) consisting of the vastus intermedius, vastus lateralis, vastus medialis and the rectus femoris, was then removed as one muscle system. The obliquus abdominis internus and the tensor fasciae latae were pulled forward to allow the knuckle to be "seamed out" between the sartorius and the vastus medialis on the

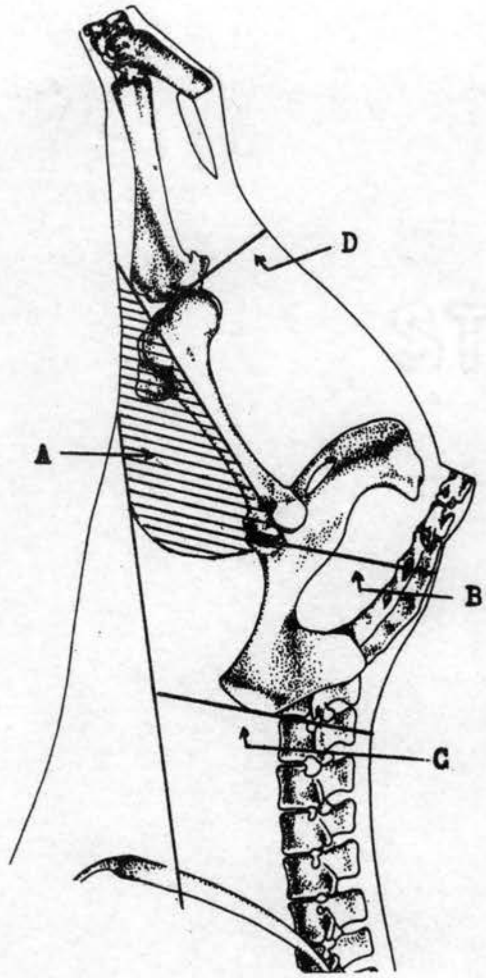


Figure 1 - Method of Sectioning the Hind-Quarter

medial side and between the biceps femoris and the vastus lateralis on the lateral side. After the knuckle had been removed, patella included, the external fat was trimmed and the patella was taken off by cutting perpendicular to the long axis of the knuckle at the proximal edge of the patella.

Loin

The loin was then separated from the round by cutting along a line (B, Figure 1) one-half inch forward of the aitch bone and between the fourth and fifth sacral vertebrae.

The psoas major, psoas minor and ilio psoas were removed from the ventral side of the loin. The psoas minor was removed from this three muscle system and classified as thin meat. The remaining muscles, the ilio psoas and psoas major, made up the tenderloin. The posterior end of the tenderloin was trimmed to two inches in thickness, at the time of trimming, whereas the anterior end was trimmed to one and one-half inches in thickness. This was the only exception made to the two inch minimum thickness requirement for thick meat in the hind quarter.

The loin was further divided into the sirloin and short loin by cutting along a line (C, Figure 1) between the fifth and sixth lumbar vertebrae and just in front of the hip bone.

The hip bone and sacral vertebrae were then removed from the sirloin and the tensor fasciae latae and obliquus abdominis internus were removed at the natural seam where they joined the gluteus medius, leaving the top sirloin, (top-butt). The posterior and dorsal sides of the top-butt required further trimming in accordance with the two inch thickness requirement.

The strip loin was prepared from the shortloin. The lumbar vertebrae and thirteenth thoracic vertebra were removed leaving the boneless "strip" (longissimus dorsi muscle). The multifidus dorsi muscle was separated from the longissimus dorsi and classified a thin meat. The strip was trimmed of external fat in excess of one-fourth inch and the flank remaining with the strip was cut on a line starting at the ventral edge of the longissimus dorsi at the posterior end to one inch below the ventral edge of the longissimus dorsi at the anterior end.

Round

The remaining portion of the pelvic bone was removed from the round. The hind shank was removed at the stifle joint (D, Figure 1) and boned. The cushion round (rump on) was then separated into the top and bottom round muscle systems by following the natural seam between the two cuts. The *gracilis* was removed from the top round leaving the *semimembranosus* and the *adductor*, referred to here as the top round. The bottom round muscle system was then separated into the *biceps femoris* (bottom round) and the *semitendinosus* (eye of the round).

FORE-QUARTER

With the fore-quarter on the cutting table, "bone side" down, the rib and plate were separated from the chuck, brisket and fore-shank by cutting between the fifth and sixth ribs, perpendicular to the spinal column.

Rib and plate

The rib and plate were separated by starting at a point six inches from the ventral edge of the *longissimus dorsi* at the posterior end and cutting parallel to the spinal column. It should be pointed out, however, that this was not a critical separation insofar as thick and thin meats were concerned, since the rib was trimmed again with the *longissimus dorsi* as a reference after the wholesale rib had been boned. The plate was separated into lean, fat and bone. All of the lean in the plate was classified as thin meat.

The rib roast was prepared from the boneless rib by trimming the external fat and cutting from a point one and one-half inches from the ventral edge of the posterior end of the *longissimus dorsi* to a point one inch from the ventral edge of the anterior end of the *longissimus dorsi*.

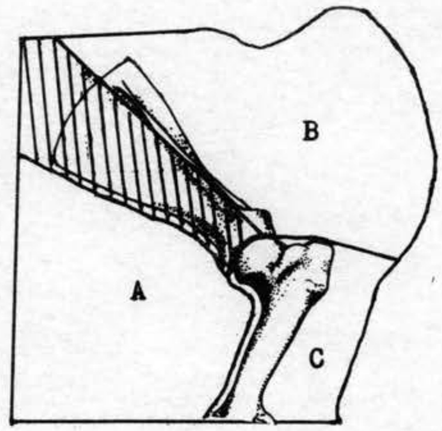


Figure 2 - Method of Sectioning the Square-Cut Chuck

Chuck

The shank and brisket were removed from the chuck immediately dorsal to the lateral condyle of the humerus. The shank and brisket were further separated into lean, fat and bone.

The square-cut chuck was then placed on the cutting table, muscle side down, and the cervical vertebrae, thoracic vertebrae and ribs were removed. The chuck was then separated into three sections, Figure 2, from which the chuck roasts were prepared. Section A was separated from sections B and C by cutting along the ventral side of the spinous process of the scapula, peeling the infraspinatus "down" to the ventral edge of the scapula and then cutting perpendicular to the cutting table following the ventral edge of the scapula and the posterior edge of the humerus. Sections B and C were separated by cutting through the humerus-scapula junction following a line perpendicular to the long axis of the humerus. The scapula was then removed from section B.

From section A, two roasts were prepared by cutting on a line two inches ventral and parallel to the position of the ventral edge of the scapula before section A was removed from sections B and C. The dorsal portion of section A was then rolled and tied. The ventral portion of section A was further divided between the deep pectoral and the triceps brachii. The deep pectoral and the intercostal muscles were separated as thin meat. The triceps brachii muscle system was classified as thick meat.

The humerus was removed from section C along with as much seam fat as possible. This entire section was classified as thin meat.

The trapezius, supraspinatus, prescapular lymph gland and surrounding fat were removed from section B. An exception was made to the three inch thickness requirement for fore-quarter thick meat and the supraspinatus was considered thick meat, even though it did not meet the requirements for thick meat, because of its desirable quality. Section B was further divided into two roasts by cutting along its long axis perpendicular to the cutting table.

Analysis of Data

The data were analyzed as a paired experiment according to the methods described by Steel and Torrie (1960) with differences between pairs comprizing the observations. Percentage of total lean, thick meat, thin meat, fat and bone, as well as all other individual muscles and muscle systems were determined as a percentage of the streamlined carcass weight, since kidney, pelvic and heart fats contribute little to visual appraisals for conformation. Mean values, mean differences and standard errors were determined for all pertinent data. In addition, thick meat, thin meat, total muscle, ratio of thick meat to bone and ratio of total muscle to bone were adjusted to a standard separable fat content for both carcass conformation groups, utilizing the covariance analysis described by Snedecor (1946).

RESULTS AND DISCUSSION

While the primary objective of this study was to determine the effect of carcass conformation on percentage yields of thick and thin meats, using carcasses that were selected to differ in conformation grade, other aspects were also considered. They included: a covariance study holding separable fat constant over both conformation groups; thick meat and total lean to bone ratios; comparison of the yields and measurements of certain individual muscles and muscle systems; and the computing of simple correlations between thick meat, thin meat, fat and bone of the left and right sides for the twenty carcasses involved.

The averages of some of the paired carcass characteristics of each group of carcasses are shown in Table II.

TABLE II

COMPARISON OF AVERAGE CARCASS CHARACTERISTICS

	Conformation		
	Low Choice	High Standard	Pooled Standard Deviation
Carcasses (no.)	10	10	
Marbling score[a]	6.1	6.6	1.3
Fat thickness - 12th rib (in.)	0.35	0.29	0.12
Ribeye area (sq. in.)	12.79	11.26	1.33
Carcass weight (lb.)	599.78	600.34	31.19
Kidney, pelvic and heart fat (lb.)	24.40	33.01	7.39

[a]Marbling was scored on a 1-12 number scale, 1 = devoid and 12 = extremely abundant.

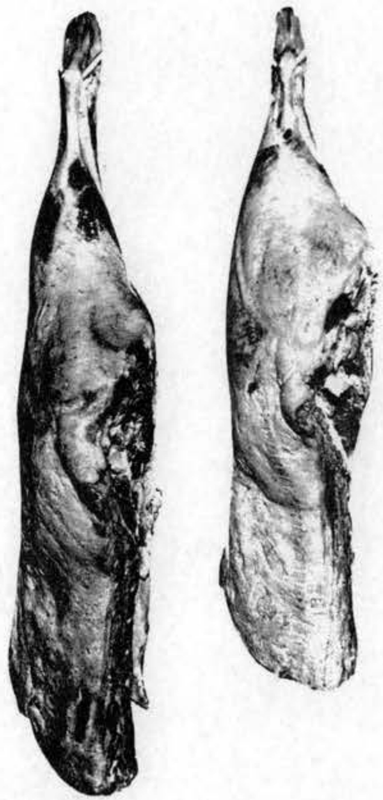
With the exception of kidney, pelvic and heart fats (Table II), paired carcass characteristics were selected visually with reasonable accuracy. Due to the inability to consistantly pair the carcasses on kidney, pelvic and heart fats, all traits studied were expressed as a percentage of the streamlined carcass weight (i.e. carcass with kidney, pelvic and heart fats removed, since these contribute little to visual appraisal for conformation). The choice conformation carcasses were much more compact, blocky and muscular in appearance than the standard conformation carcasses. Plates I and II contrast visual differences in conformation between the two carcass groups.

Yields of thick and thin meats and of total lean, fat and bone are summarized in Table III. The unadjusted mean difference (unadjusted for differences in separable fat between the two conformation groups) of 0.93 percent in yields of thick meat, 31.50 and 30.57 percent for the choice and standard conformation groups respectively, was significant at the .05 level of probability. This indicated that there was a small, but real advantage for choice conformation over standard conformation in terms of the yield of high value steak and roast meat (thick meat). This finding is constrasted by a study reported by Kroph and Graf (1959). Working with U.S.D.A. Choice, Good and Standard grade carcasses, they found boneless beef yields lowest for the Choice grade. However, in this work no attempts were made to standardize fat.

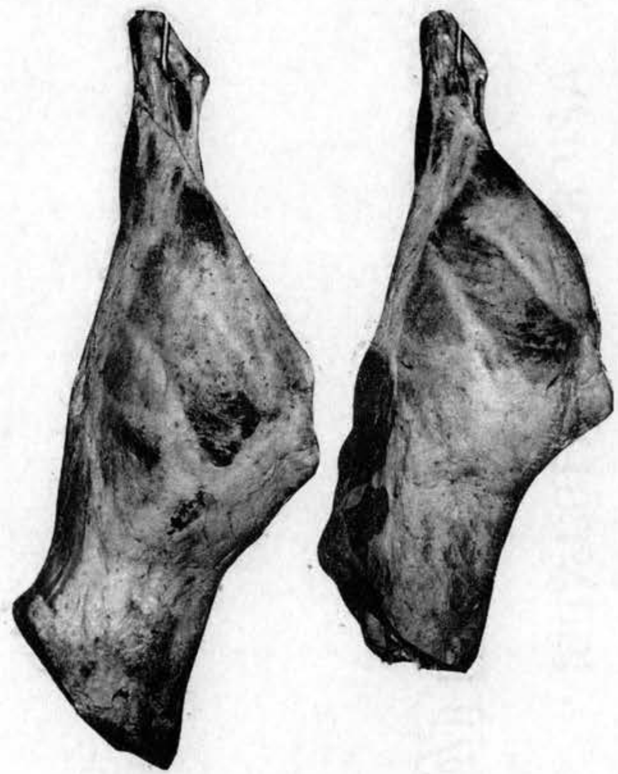
Standard conformation carcasses were observed to have a slightly higher percentage of thin meat than choice conformation carcasses. The unadjusted mean difference of 0.82 percent, 35.43 and 34.61 percent for the standard and choice conformation carcasses respectively, was statistically significant, $P < .05$.

PLATE I

COMPARISON OF CHOICE AND STANDARD HIND-QUARTER CONFORMATION



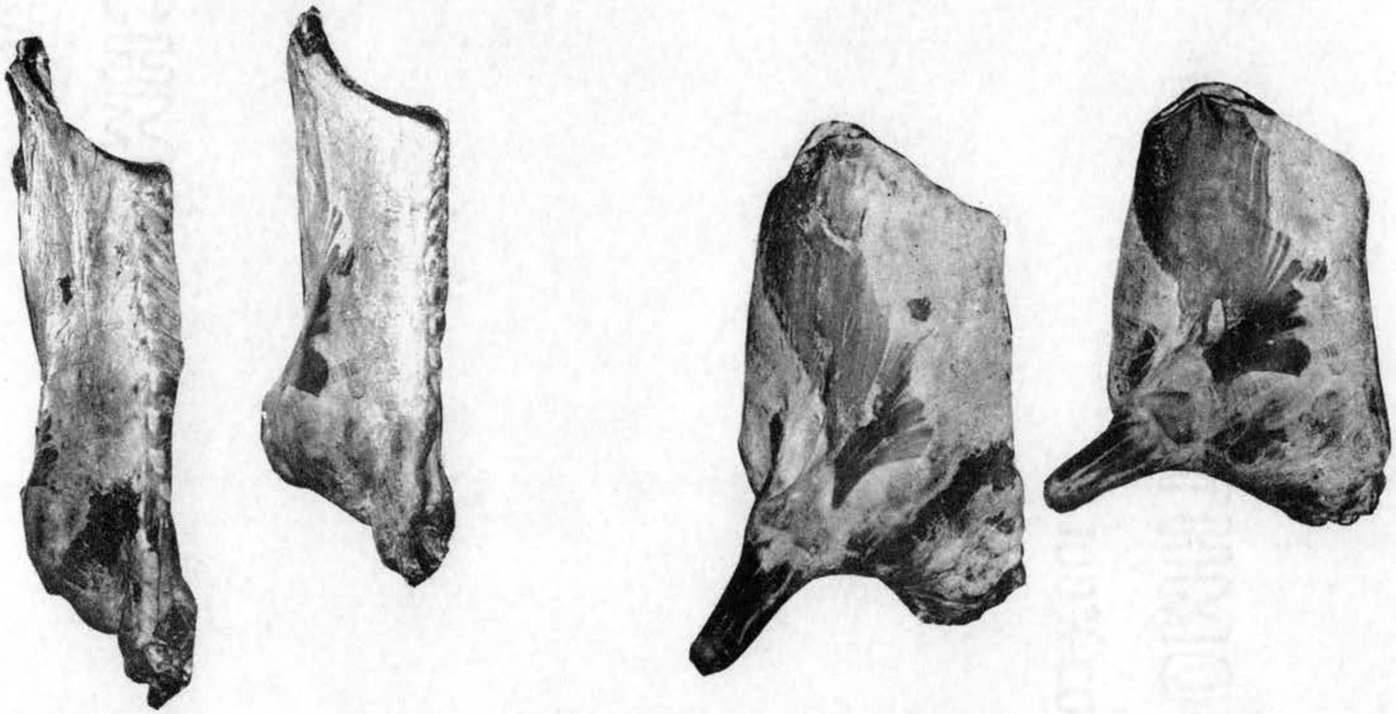
Standard Choice
Dorsal View



Standard Choice
Lateral View

PLATE II

COMPARISON OF CHOICE AND STANDARD FORE-QUARTER CONFORMATION



Standard Choice
Dorsal View

Standard Choice
Lateral View

TABLE III

UNADJUSTED MEANS[a] AND MEAN DIFFERENCES OF AVERAGE PERCENTAGE YIELDS OF "THICK AND THIN MEATS" AND OF TOTAL LEAN, FAT AND BONE

Trait[b]	Carcass Conformation Choice Percent	 Standard Percent	Mean Difference Choice Minus Standard Percent
"Thick meat"	31.50	30.57	0.93*
"Thin meat"	34.61	35.43	-0.82*
Total lean[c]	66.11	66.00	0.11
Total fat	19.48	16.88	2.60*
Total bone	14.39	17.11	-2.72**

[a]Means are unadjusted for differences in separable fat between the two conformation groups.

[b]All traits are expressed as a percentage of the streamlined carcass weight.

[c]The sum total of thick and thin meat.

$^{*}P < .05$

$^{**}P < .01$

Total lean yields (the sum of thick and thin meat yields unadjusted for differences in separable fat) were almost identical and not significantly different, 66.11 percent for the choice carcasses and 66.00 percent for the standard carcasses. Thus, the lean content of beef carcasses, differing in conformation but of similar weights, was relatively constant and the fat and bone were the major variables. Similar conclusions have been reported by Moulton (1933), Callow (1949) and Murphy (1960), with respect to fat being the major variable of the three primary tissues (lean, fat and bone) of the beef carcass.

The two groups differed considerably in yields of fat and bone. Choice conformation carcasses had on the average 2.60 percent more separable fat and fat trim than the standard conformation carcasses. However, this difference of 2.60 percent more fat for the choice conformation carcasses was offset by a lower percentage of bone. The choice conformation carcasses had on the average 2.72 percent less bone than the standard conformation carcasses, 14.39 percent bone for the choice and 17.11 percent for the standard carcasses.

The combined percentages of fat and bone, 33.87 and 33.99 percent for the choice and standard carcasses respectively, were observed to make up a rather constant percentage of the streamlined carcass weight.

Thus, the almost identical percentage yields of total lean, 66.11 for the choice and 66.00 for the standard carcasses, are the results of the almost constant combined percentages of fat and bone for the two groups. As percentage bone decreased, fat increased. A similar conclusion was reached by Tyler _et al_. (1964).

Since attempts to hold separable fat and fat trim constant for both conformation groups by selection were not entirely successful, a covariance analysis was employed to adjust both conformation groups to a common separable fat content. Using this analysis, the adjusted mean difference in thick meat was 1.52 percent, as compared to 0.93 percent unadjusted (Table IV). This increased the advantage in thick meat for the choice carcasses over the standard carcasses and the probability of a difference of this magnitude being due to chance became less, $P < .01$ adjusted as compared to $P < .05$ unadjusted.

When the necessary adjustments were made in the thin meat yields to correct for differences in separable fat between the two groups, the 0.82 percent difference in thin meat, standard minus choice, reversed to 0.28 percent more thin meat for the choice conformation carcasses, however this difference was not statistically significant. This points out, however, that on a fat constant basis, advantage in conformation grade results in an increase in both thick and thin meat in comparing carcasses similar in weight, but distinctly different in conformation grade.

Mean yields for adjusted total lean of 66.92 and 65.21 for the choice and standard conformation carcasses respectively, resulted in a difference of 1.71 percent. This difference was significant at the .05 level of probability, whereas, on an unadjusted basis, the mean difference in total lean was non-significant (Table IV).

Ratio of lean to bone is a common descriptive term often employed by those engaged in the evaluation of beef carcasses, to indicate desirable conformation. In this study, the low choice conformation carcasses had an average ratio (fat adjusted) of thick meat to bone of

TABLE IV

COMPARISON OF SOME UNADJUSTED AND ADJUSTED[a] MEAN PERCENTAGE YIELDS

	Unadjusted Mean Y_u		Adjusted Mean $Y_a = Y_u - bx$ [b]		Mean Difference Choice Minus Standard	
Trait	Choice Percent	Standard Percent	Choice Percent	Standard Percent	Unadjusted Percent	Adjusted Percent
"Thick meat"	31.50	30.57	31.80	30.28	0.93*	1.52**
"Thin meat"	34.61	35.43	35.16	34.88	-0.82*	0.28
Total lean	66.11	66.00	66.92	65.21	0.11	1.71*

[a]Both conformation groups adjusted to the same separable fat equivalent.

[b]Adjusted $Y_a = Y_u - bx$, where b is the regression coefficient of fat on each trait respectively over both conformation groups and x is the percent choice and standard deviate from the over all separable fat mean.

*$P < .05$

**$P < .01$

2.17:1. The ratio of thick meat to bone for the standard conformation carcasses was 1.83:1. The difference in these ratios of 0.34:1 was statistically significant, P < .01. McMeekan (1956) suggested that the ratio of lean to bone is relatively constant for meat animals and that a strong relationship exists between bone weight and muscle weight. This study fails to substantiate this earlier finding.

Adjusted ratio values of 4.55:1 and 3.90:1 were obtained when the ratios of total lean to bone were calculated for choice and standard carcasses respectively. The ratio difference of 0.65:1 (total lean to bone ratio) was highly significant, P < .01. Similar ratios of boneless beef yield to bone have been reported by Kropf and Graf (1959) and Tyler et al. (1964) in comparing carcasses that differed widely in conformation.

Muscle and muscle system yield comparisons were made between the two conformation groups. A summary of these comparisons is presented in Table V. Choice conformation carcasses were found to have higher percentage yields in all muscles studied except two, the tenderloin and knuckle. Choice carcasses had significantly more top-butt and bottom round (P < .05 and .01 respectively). This finding is of interest since the top-butt (sirloin) and the bottom round (out-side round) are two muscle systems that are viewed directly when one makes a visual appraisal for carcass conformation. These data suggest that both the bottom round and/or top-butt may have more influence on conformation appraisals than some of the other muscles in the hind-quarter.

Differences in length, width and depth measurements of muscles and muscle systems were quite pronounced. In general, the standard conformation carcasses produced longer, wider, thinner muscles and

TABLE V

PERCENTAGE YIELD MEAN VALUES, MEAN DIFFERENCES AND STANDARD DEVIATIONS OF MEANS AND OF MEAN DIFFERENCES FOR INDIVIDUAL HIND-QUARTER MUSCLES AND MUSCLE SYSTEMS

	Carcass Conformation				Mean Difference	
	Choice		Standard		Choice Minus Standard	
Trait[a]	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
Tender loin	0.97	0.13	1.03	0.08	-0.06	0.05
Strip loin	2.68	0.24	2.56	0.11	0.12	0.08
Top-butt	2.69	0.21	2.49	0.12	0.20*	0.08
Knuckle	3.16	0.22	3.19	0.26	-0.03	0.11
Top round	3.75	0.24	3.75	0.26	0.00	0.12
Bottom round	2.87	0.23	2.46	0.22	0.41**	0.09
Eye round	1.33	0.08	1.31	0.13	0.02	0.06

[a]All traits are expressed as a percentage of the streamlined carcass weight.

*$P < .05$

**$P < .01$

muscle systems than the choice carcasses. However, the majority of the standard muscles and muscle systems lost this advantage in length and width when the muscles were trimmed in accordance with the two inch minimum thickness requirement for thick meat in the hind-quarter. Muscle length, width and depth measurements are summarized in Table VI. Without exception, muscles and muscle systems of the choice conformation carcasses were thicker than the standard conformation muscles and muscle systems. The bottom round, top-butt and strip loin were significantly thicker.

Since the muscles from the standard conformation carcasses were longer than the corresponding choice conformation carcasses, bone lengths of the two groups would be expected to correspond. The average femur length for the choice carcasses was 13.2 inches as compared to an average of 15.0 inches for the standard carcasses. The difference of 1.8 inches in average femur length was statistically significant, $P < .01$. The tibia was observed to follow the same pattern as the femur, 11.5 inches and 13.4 inches for the choice and standard carcasses respectively. The difference of 1.9 inches in mean tibia length was statistically significant, $P < .01$. These differences in bone length, coupled with the fact that the mean percentage of total lean for the two groups varied less than two percent, suggested that the standard conformation carcasses have almost as much total lean as the choice conformation carcasses, but that the muscles were stretched over longer bones and by necessity they were thinner than the corresponding choice conformation muscles.

In this study, the choice conformation carcasses had a much higher ratio of thick meat to bone and total lean to bone than the standard

TABLE VI

SOME MEAN LENGTH, WIDTH AND DEPTH MEASUREMENTS[a] OF SELECTED MUSCLES AND MUSCLE SYSTEMS

	Length Measurements					
	Choice		Mean Difference[d]			
Trait	Rough[b] Inches	Trimmed[c] Inches	Rough Inches	$s_{\bar{d}}$ [e]	Trimmed Inches	$s_{\bar{d}}$ [e]
Tender loin	21.77	13.33	2.30**	.43	-1.43**	.29
Eye round	14.95	10.78	0.93**	.24	-0.65*	.25
Bottom round	22.38	15.90	1.19	.38	0.31	.37
Top round	15.59	12.16	0.86**	.16	-0.55**	.17
Strip loin	-----	15.20	----	---	1.54**	.18

	Width Measurements		
	Choice	Mean Difference[d]	
Trait	Trimmed Inches	Inches	$s_{\bar{d}}$ [e]
Bottom round	6.23	-.60**	.14
Top round	11.70	-.28	.19

	Depth Measurements		
	Choice	Mean Difference[d]	
Trait	Trimmed Inches	Inches	$s_{\bar{d}}$ [e]
Bottom round	3.78	-.28**	.08
Top-butt	4.48	-.35**	.04
Top round	3.97	-.05	.07
Knuckle	4.22	-.06	.11
Strip loin (anterior end)	2.39	-.18*	.08
Strip loin (posterior end)	2.66	-.15	.07

[a]Length and width measurements were recorded to the nearest ¼ inch, depth was recorded to the nearest 1/10 inch.

[b]Rough refers to the muscles before they were trimmed in accordance with thick meat requirements.

[c]Trimmed refers to the muscles after they were trimmed in accordance with thick meat requirements.

[d]The amount standard conformation muscles deviate from choice muscles.

[e]Standard error of the difference of means.

*$P < .05$

**$P < .01$

carcasses. Thus it follows from these data that among carcasses of the same degree of fatness, the heavier muscled carcasses will have a higher yield of high value cuts. It appears that a basic reason for thin muscled, low conformation carcasses having favorable cut-outs, under some cutting evaluation techniques, is their low degree of fatness, when no corrections are made for differences that exist in fatness among carcasses.

Correlation coefficients between thick meat, thin meat, fat and bone of the left and right sides were computed for the twenty carcasses involved in this study. These correlations provided information relating to the repeatability of the cutting technique used. Simple correlation coefficients between thick meat, thin meat, fat and bone of the left and right sides were 0.97, 0.87, 0.98 and 0.94 respectively, indicating that a high degree of repeatability was associated with the cutting technique. These relationships would imply that, using this technique and working with well split carcasses, either side could be used as a reliable indicator of the composition of the entire carcass.

SUMMARY AND CONCLUSIONS

Ten pairs of low choice and high standard conformation steer carcasses, paired as closely as possible on carcass weight, rib eye area, fat thickness at the twelfth thoracic vertebra and estimated percentage kidney, pelvic and heart fats, were used to study a new concept in beef carcass evaluation. This concept is unique in that high value steak and roasts, referred to herein as thick meat, rather than percentage lean, trimmed wholesale cuts or conventional retail yield, was used as the criteria of carcass merit. Thick meat consisted of the muscle systems of the fore-quarter three inches or more in depth, considered suitable for roasts, plus the muscles and muscle systems of the hind-quarter two inches or more in depth, considered suitable for steak.

Results indicated that there was a small but significant advantage for choice conformation over standard conformation in yield of thick meat. When both conformation groups were corrected to the same fat equivalent basis, the advantage in thick meat for choice conformation increased. Furthermore, on a fat adjusted basis, the choice carcasses had more thin meat, more total lean, less bone and a higher ratio of thick meat and total lean to bone than the standard carcasses.

Before adjustments were made for differences in separable fat between the two groups, the combined weight of bone and fat was observed to make up a rather constant percentage of the streamlined carcass weight. This suggested that, within limits, total lean may be relatively constant over a range of carcass shapes and that bone and fat are the major variables. However, this does not rule out carcass conformation as a useful estimate of muscling. The choice conformation carcasses had a much higher ratio of thick meat and total lean to bone than the standard conformation carcasses. It was obvious that 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, to the lower grading conformation carcasses.

Certain length, width and depth measurements associated with the corresponding muscles and muscle systems of the two conformation groups were studied. The standard conformation carcasses produced longer, wider, thinner muscles and muscle systems than the choice carcasses. However, advantages in length and width for the standard carcasses disappeared when the muscles were trimmed in accordance with minimum thickness requirements for thick meat.

The skeletal structure of the two conformation groups was observed to follow the same pattern as that of the muscles and muscle systems. Choice carcasses were observed to have shorter bones than standard carcasses.

Simple correlations between the right and left sides for thick meat, thin meat, fat and bone of the twenty carcasses studied, were high. These correlations indicated that the cutting procedure followed was quite repeatable and that one side would provide a good estimate of the entire carcass.

LITERATURE CITED

Branaman, G. A., O. G. Hankins, and L. M. Alexander. 1936. The relation of degree of finish in cattle to production and meat factors. Proc. Am. Soc. Animal Prod. 295-300.

Branaman, G. A., A. M. Pearson, W. T. Magee, Ruth M. Griswold, and G. A. Brown. 1962. Comparison of the cutability and eatability of beef and dairy cattle. J. Animal Sci. 21:321.

Breidenstein, B. C. 1962. More definitive system is needed to predict retail yield of beef carcass. National Provisioner Convention Issue. p. 77.

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

Bulter, O. D. 1957. The relation of conformation to carcass traits. J. Animal Sci. 16:227.

Cahill, V. R., B. D. Van Stavern, L. E. Kunkle, and Earl W. Klosterman. 1959. Evaluation of carcasses sired by long bodied and short bodied bulls. J. Animal Sci. 18:1478. (Abstr.).

Callow, E. H. 1948. Comparative Studies of Meat. The changes in the carcass during growth and fattening, and their relation to the chemical composition of the fatty and muscular tissue. J. Agr. Sci. 38:174.

Callow, E. H. 1949. Comparative Studies of Meat III. Rates of fattening in relation to the percentage of muscular and fatty tissues in a carcass. J. Agr. Sci. 39:347.

Callow, E. H. 1961. Comparative Studies of Meat VII. A comparison between Hereford, Dairy Shorthorn and Fresian steers on four levels of nutrition. J. Agr. Sci. 56:265.

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

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

Cole, J. W., C. B. Ramsey, C. S. Hobbs, and R. S. Temple. 1964. Effects of type and breed of British, Zebu and dairy cattle on production, palatability, and composition, III. Percent wholesale cuts and yield of edible portion as determined by physical and chemical analysis. J. Animal Sci. 23:71.

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

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

Hammond, J. H. 1921. On the relative growth and development of various breeds and crosses of sheep. J. Agr. Sci. 11:367.

Hammond, J. H. 1933. How science can help improve the nation's food supply. Society of Chemical Industries J. 52:637.

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

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

Kemp, J. D., E. J. Wilford, and W. P. Garrigus. 1954. Carcass characteristics of heavy calves produced by the Kentucky cow and calf plan. J. Animal Sci. 13:970.

Kidwell, J. F. and J. A. McCormick. 1956. The influence of size and type on growth and development of cattle. J. Animal Sci. 15:109.

Kidwell, J. E., J. E. Hunter, P. R. Ternan, and J. E. Harper. 1959. Relation of production factors to conformation scores and body measurements, associations among production factors and the relation of carcass grade and fattness to consumer preferences in yearling steers. J. Animal Sci. 18:894.

King, G. T., O. D. Bulter, and L. D. Wythe, Jr. 1959. A new method of cutting beef carcasses to determine accurately the yield of red meat in the carcass. J. Animal Sci. 18:1479. (Abstr.).

Knox, J. H. 1957. Interrelations of type, performance, and carcass characteristics. J. Animal Sci. 16:240.

Kropf, D. H. and R. L. Graf. 1959. The effect of carcass grade, weight and classification upon boneless beef yield. J. Animal Sci. 18:95.

Laws, J. B. and H. H. Gilbert. 1860. On the composition of oxen, sheep and pigs and of their increase whilst fattening. J. Roy. Ag. Soc. Eng. 21:433.

Malkus, L. A. 1964. Changes in carcass composition from 9 to 18 months in heifers fed a fattening ration. Ph. D. Thesis, Oklahoma State University, Stillwater, Oklahoma.

McMeekan, C. P. 1940. Growth and development in the pig with special reference to carcass quality. J. Agr. Sci. 30:276.

McMeekan, C. P. 1942. Growth and development in the pig with special reference to carcass quality. J. Agr. Sci. 31:1.

McMeekan, C. P. 1956. Beef carcass judging by measurement. Pastoral Review and Grazier Rec. 66:1273.

Moulton, C. R. 1933. Age and chemical development in mammals. J. Biol. Chem. 57:79.

Murphy, C. E., D. K. Hallett, W. E. Tyler, and J. C. Pierce, Jr. 1960. Estimating yields of retail cuts from beef carcasses. J. Animal Sci. 19:1240.

Orme, L. E. and A. M. Pearson. 1959. The muscle-bone relationship in beef. J. Animal Sci. 18:1271.

Orts, Frank A. and G. T. King. 1959. Cannon bone characteristics as related to muscle in beef carcasses. J. Animal Sci. 18:1479. (Abstr.).

Palsson, H. 1939. Meat qualities in sheep with special reference to Scotish breeds and crosses. J. Agr. Sci. 29:544.

Pierce, J. C. 1957. The influence of conformation, finish, and carcass weight on the percentage yield of wholesale and retail cuts. Proc. 10th Annual Reciprocal Meat Conf. 10:119.

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

Snedecor, G. W. 1946. Statistical Methods (4th ed.). Iowa State College Press, Ames, Iowa.

Steel, Robert G. D. and James H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Company, New York, New York.

Stonaker, H. H., M. H. Hazaleus, and S. S. Wheeler. 1952. Feedlot and carcass characteristics of individually fed compress and conventional type Hereford steers. J. Animal Sci. 11:17.

Tyler, W. E., D. K. Hallett, C. E. Murphy, K. E. Hoke, and B. C. Breidenstein. 1964. Effects of variation in conformation on cutability and palatability on beef. Presented at the fifty-sixth meeting of the American Society of Animal Science, Knoxville, Tennessee.

Wellengton, G. H. 1953. Recommended procedure for cutting beef. Proc. 6th Annual Reciprocal Meat Conf. 6:73.

Willey, N. B., O. D. Bulter, J. K. Riggs, J. H. Jones, and P. J. Lyerly. 1951. The influence of type on feedlot performance and killing qualities of Hereford steers. J. Animal Sci. 10:195.

Wythe, J. D., Jr., F. A. Orts, and G. T. King. 1961. Bone-muscle relationships in beef carcasses. J. Animal Sci. 20:3.

Ziegler, Thomas P. 1958. The Meat We Eat (5th ed.). Interstate Printing and Publishing Co., Inc., Danville, Illinois.

Zinn, D. W., H. Elliott, D. Burnett, and R. M. Durham. 1961. Evaluation of U.S.D.A. beef grading methods. Am. Soc. Animal Prod. 20:922.

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

APPENDIX

TABLE VII

Characteristics of Individual Carcasses

Carcass Number[a]	Chilled Carcass Weight Pounds	Rib Eye Area Sq. Inches	Fat Thickness 12th Rib Inches	Degree of Marbling[b]	Pelvic, Kidney and Heart Fats Pounds	"Streamlined Carcass Weight"[c] Pounds
021	611.3	11.74	0.25	6	26.0	582.5
022	611.8	10.57	0.48	6	25.3	581.3
031	570.9	13.36	0.25	6	21.6	545.3
032	576.4	12.79	0.08	5	25.0	547.1
041	538.3	11.47	0.36	6	20.2	516.1
042	531.0	9.98	0.43	6	25.5	502.3
051	579.8	13.51	0.36	5	20.0	557.0
052	570.5	9.57	0.30	6	35.6	530.8
061	602.5	14.07	0.30	7	21.7	576.9
062	611.5	11.59	0.36	4	22.7	586.3
071	614.5	14.11	0.36	7	22.6	589.7
072	631.0	12.17	0.15	10	40.4	585.8
081	617.5	12.60	0.30	6	18.9	596.4
082	620.0	13.50	0.20	9	42.4	572.7
091	613.0	13.76	0.26	6	24.2	585.2
092	625.5	11.97	0.33	7	35.1	584.5
101	647.8	12.93	0.44	6	39.4	605.8
102	629.3	11.19	0.40	7	40.4	587.0
111	602.5	10.35	0.62	6	16.3	583.9
112	596.5	9.29	0.20	6	20.2	573.6

[a]The first two digits of the carcass number designates the pair number. The third digit designates the conformation grade (i.e., 1=choice conformation, 2=standard conformation).

[b]Marbling was scored on a 12 point system, 1=practically devoid and 12=extremely abundant.

[c]The failure of "streamlined carcass weight" plus the weight of pelvic, kidney and heart fats to equal chilled carcass weight represents shrink and cutting loss.

TABLE VIII

Yields[a] of Muscles and Muscle Systems
for Individual Carcasses

	Percentage of								
Carcass Number[b]	Strip Loin	Tender Loin	Top Butt	Knuckle	Top Round	Bottom Round	Eye Round	Rib Roast	Chuck Roast
021	2.87	0.96	2.56	3.43	3.62	2.85	1.29	3.79	9.87
022	2.65	1.17	2.41	3.22	3.78	2.32	1.32	3.99	10.13
031	2.66	1.03	2.94	3.33	3.65	3.38	1.28	4.13	10.73
032	2.46	1.05	2.64	3.73	3.81	2.57	1.23	4.05	9.27
041	2.43	1.05	2.89	3.45	3.53	2.99	1.26	3.86	9.99
042	2.50	1.07	2.49	2.83	3.38	2.54	1.50	3.76	10.33
051	2.77	0.85	2.94	2.94	3.72	2.69	1.32	3.79	9.65
052	2.62	1.06	2.39	3.04	3.63	2.45	1.17	4.14	9.61
061	3.17	1.11	2.67	2.96	4.10	2.83	1.40	4.02	9.90
062	2.52	1.03	2.70	3.40	3.87	2.66	1.45	3.46	8.36
071	2.64	1.17	2.88	3.32	4.21	2.95	1.48	4.05	10.07
072	2.52	0.94	2.29	3.07	3.48	2.10	1.14	4.63	11.32
081	2.49	0.86	2.55	2.85	3.64	2.65	1.34	3.69	10.51
082	2.67	1.01	2.54	3.09	3.79	2.50	1.21	4.28	9.83
091	2.80	0.86	2.52	3.20	3.72	2.64	1.31	4.02	10.31
092	2.77	0.90	2.40	2.93	3.52	2.11	1.36	4.04	9.18
101	2.68	1.05	2.53	3.04	3.85	3.04	1.40	3.62	9.60
102	2.38	1.08	2.48	3.27	3.96	2.63	1.25	3.76	9.80
111	2.30	0.80	2.38	3.08	3.50	2.71	1.22	3.79	10.99
112	2.53	1.03	2.56	3.37	4.25	2.76	1.46	3.77	9.76

[a]Yields are based on "streamlined carcass weights".

[b]The first two digits of the carcass number designates the pair number. The third digit designates the conformation grade (i.e., 1=choice conformation, 2=standard conformation).

TABLE IX

Yields[a] of Major Components for Individual Carcasses

Carcass Number[b]	Percentage of "Thick Meat"	Percentage of "Thin Meat"	Percentage of Fat	Percentage of Bone
021	31.24	34.10	20.70	13.90
022	31.00	36.40	15.50	17.10
031	33.12	36.39	16.44	14.04
032	30.80	37.28	13.58	18.31
041	31.44	36.65	17.20	14.71
042	30.40	35.50	19.35	14.75
051	30.67	34.96	18.94	15.42
052	30.11	35.50	18.64	15.75
061	32.24	35.64	18.23	13.89
062	29.60	36.16	15.35	18.89
071	32.78	35.32	17.47	14.43
072	31.48	35.04	18.60	14.88
081	30.74	33.86	21.54	13.85
082	30.93	35.81	16.94	16.33
091	31.38	33.74	20.23	14.64
092	29.29	34.14	20.17	16.40
101	30.81	32.11	23.08	13.99
102	30.61	34.10	16.12	19.16
111	30.77	33.30	20.93	15.00
112	31.50	34.40	14.60	19.49

[a]Yields are based on "streamlined carcass weights".

[b]The first two digits of the carcass number designates the pair number. The third digit designates the conformation grade (i.e., 1=choice conformation, 2=standard conformation).

VITA

Everett Lawton Martin

Candidate for the Degree of

Master of Science

Thesis: EFFECT OF BEEF CARCASS CONFORMATION ON THICK AND THIN MEAT YIELDS

Major Field: Food Science

Biographical:

Personal Data: Born in Haworth, Oklahoma, October 2, 1941, the son of Ernest L. and Erma Jo Martin; married Gloria Ann Calfee, August 19, 1962; father of one son, Mark Everett Martin.

Education: Attended grade school in Haworth, Oklahoma; was graduated from Haworth High School in 1959; received the Bachelor of Science from Oklahoma State University with a major in Animal Husbandry, and a commission in the United States Army, in May, 1963.

Experience: Raised and worked on a livestock farm in Oklahoma; part time meat cutter, Oklahoma State University Meat Laboratory, 1959-1963; graduate assistant, Animal Science Department, Oklahoma State University, 1963-1965.