THE RELATIONSHIP BETWEEN VARIOUS PHYSICAL FACTORS OF SWINE CARCASS CHARACTERISTICS

by

GERALD R. HEGARTY

B. S., Kansas State University, 1954

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Husbandry

KANSAS STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE

1960

TABLE OF CONTENTS

INTRODUCTION

The modern housewife's demand for leaner pork has resulted in a broad price differential between the fat and lean cuts of pork. The increased consumer acceptance of vegetable shortenings as lard substitutes has substantially lowered the price of lard. In order to meet the demand for less fat and more lean, the need for reliable measures of the fat and lean content of pork carcasses is warranted.

The external appearance of the live hog or the external appearance of the intact carcass is often misleading in predicting its composition. Several linear measurements are used in research and by the packing industry as indices of the fat and lean content of pork carcasses. Thickness of backfat is the characteristic most commonly used to predict the relative proportions of fat and lean in swine carcasses. Carcass length and weight are factors frequently used in conjunction with backfat thickness to predict carcass cutout. Yield of the four lean cuts expressed as a percent of the cold carcass weight is frequently used as a standard to establish the monetary value of pork carcasses. Many packer buyers base their estimates of live value on an estimated lean cut yield expressed as a percent of the live weight. Cross-sectional area of the longissimus dorsi muscle (loin eye area) is used as an index of carcass muscling in scientific carcass studies and in swine certification programs.

This study was undertaken to determine the relative value of certain physical factors of swine carcass characteristics for predicting lean and fat cutout. The relationships between these factors have also been investigated. The primary factors involved in this study were carcass length, backfat thickness, loin eye area, number of ribs, percent lean cuts, percent fat trim, and percent leaf fat. The relationship of certain factors between the right and left sides of the carcass was determined. It is known that tracings of the loin eye area are subject to a degree of variation when the tracings are made by more than one individual. The significance of this variation is also reported in this study.

REVIEW OF LITERATURE

Denmark was probably the first country to establish a progeny testing system for swine (1907). Since sows and boars used for breeding purposes could not be fattened and killed, data on their ability to produce desirable meat could not be obtained. This ability is estimated from the performance of their offspring or collateral relatives. This progeny testing system emphasized the need for certain objective measurements of bacon carcass characteristics.

Lush (1936) stated that the carcass characteristics used for comparison in the Danish system of progeny testing are: body length, thickness of backfat, thickness of belly, firmness of flesh, distribution of fat along the back, and proportion of lean meat.

Much of the early research on hog carcass characteristics was performed by British and Canadian workers in an attempt to develop a more desirable bacon pig. McMeekan (1939) reported that the external carcass characteristics do not provide a reliable indication of the internal quality status of the bacon pig. Variability appears to be affected by the rate of development of the characteristic concerned; late developing characteristics in general tend to be more variable than early developing ones. The region of the shoulders develops first and the region of the loin last, with development of the rump being intermediate.

Hammond and Murry (1937) found that the subcutaneous layer of fat in hogs matures earliest at the shoulder, over the rump next, and on the loin last. The ratio between the thickness of fat at the shoulder and at the loin decreases as the weight of the side increases. Since the region of the last rig is the latest maturing part of the body, it is at this place that the carcass should be cut in order to obtain a proper estimate of its development.

McMeekan (1941) reported that the total weight of bone, muscle, and fat in the bacon pig carcass can be estimated with a high degree of accuracy from the respective weights of these tissues in either the leg or the loin. The combination of these two joints provide even higher correlations with the total weight of bone, muscle, and fat than either one alone.

Cross-sectional linear measurements of the muscle at the junction of the thorax and loin are highly correlated with the weight of muscle in the carcass. The eye (longissimus dorsi) muscle measurement, two times the length of eye plus depth of eye, is highly correlated with the weight of muscle in the carcass. The relationship of the weight of the psoas major muscle to total muscle is sufficiently strong to justify its use as an index of muscle development.

In this study by McMeekan the following correlations were determined: eye muscle depth with weight of lean 0.5074, backfat thickness with weight of fat 0.9312 and leg length with weight of bone 0.7938.

Bennett and Coles (1946) determined simple correlation values for various characteristics of Yorkshire barrow and gilt carcasses. A significant negative correlation (-0.456) between length of side and thickness of shoulder fat, and a rather high and significantly negative correlation (-0.752) between percentage middle and percentage ham was found for both barrows and gilts.

There has been considerable speculation as to whether body length in swine is related to number of ribs. Shaw (1930) stated that the number of ribs in pigs varies from thirteen to seventeen pair. The thoracic vertebrae vary according to the number of ribs present. The usual variation in the number of lumbar vertebrae is six to seven. True ribs are always attached to thoracic vertebrae. This work indicated that length of carcass is closely associated with a variation in rib number. The animals used in these tests consisted mainly of purebred Yorkshires.

Bull and Longwell (1929) made cutting tests to determine differences in carcasses from hogs of three types: chuffy, intermediate and rangy. The differences in the average amounts of lean in the carcasses of the three types were not significant. Chuffy carcasses contained 7.3 percent less skin and the rangy carcasses 5.5 percent more skin than the intermediate carcass. According to Bull and Longwell, a coarse heavy skin is usually associated with a coarse stringy meat.

In general, the cuts from carcasses of the hand fed chuffy type contained less lean, less skin, less bone, and more fat than those of the intermediate type. The cuts of the rangy type contained more bone, more skin, and less fat than the intermediate type.

Hankins (1940) observed differences in carcasses produced by the three types of hogs (large, medium, and small). In the first series of tests the three types of hogs were slaughtered at the same weight. Increases in fatness resulted in decreases in the proportion of ham, loin, and shoulder. Carcasses of the large type yielded the highest percentage of the preferred cuts, but they were lowest in market grade. It should be noted that the market grades for swine in 1940 differed considerably from present USDA standards.

In the second series of experiments the three types were slaughtered at the same degree of fatness. The carcasses of the large type still produced the highest proportion of lean cuts, but the differences were less than one percent.

In bacon carcass studies by Sinclair and Murry (1935) carcasses were graded and length, backfat thickness, percentage of various cuts measured. In addition a cross section, averaging two inches in thickness was removed immediately posterior to the last rib, extending across the entire side. Planimeter readings of the lean and fat areas in the cross section were made and the percentage of each was determined. A high positive correlation (0.9523) was found to exist between the percentage "eye of lean" and the percentage ham. No significant correlation was found between carcass length and depth of backfat, or belly thickness and shoulder and ham percentages.

Stothart (1938) reported that length of side and depth of shoulder and backfat increased with increases in weight, while the area of lean or the product of length and width of the loin muscle decreased with increased depth of shoulder fat.

Hankins (1934) made a study on 17 hams which varied widely in plumpness. The ratio of weight of meat to bone was calculated in each instance. The coefficient representing the correlation between plumpness (measured) and the ratio of meat to bone was 0.51 ± 0.12. Considering this fact, it appears that plumpness in the average case has an effect upon the ratio of meat to bone in the ham. These studies also indicated that fatness plays an important part in plumpness.

Hankins and Ellis (1935) divided experimental hogs into three weight classes and each weight class was subdivided as to type of live hog (small, medium or large) into three types. The close relationship between the type of hog and the separable fat of the ham is especially noteworthy. As type decreased from large to small the percentage of fat of the ham increased steadily from 23.5 to 34.7. With the decrease in type from large to small there was a distinct decrease in the percentage of lean in the ham; however this decrease in lean is not as marked as the increase in fat. The percent of total edible portion of the ham increased, though not to a great extent, with the decrease in type from large to small. The hams from the small type hogs had about four percent higher proportion of edible meat than those from large type hogs.

Hankins and Ellis (1939) found that a 33.3 percent increase in live weight results in an increase of 36.7 percent in the weight of the carcass. These figures are based on results from more than 5000 normally fed hogs. Associated with increases in fatness were increases in the proportions of bacon, back and leaf fats and a decrease in proportion of ham.

Aunan and Winters (1949) stated that English workers (Hammond, et al.) in 1936 devised one of the first systems for judging pork and bacon carcasses. Thickness of eye muscle of the loin at the last rib was used as an indicator of the relative amount of lean meat throughout the carcass. These workers maintained that this is a good index of carcass development because this part of the carcass develops last during the growth of the animal.

Hutchinson, an Australian worker (1951) observed the rate of increase in eye muscle thickness to be 2.468 mm. for each twenty pounds increase in body weight. This was compared with the Hammond standard increase of 1.0 mm. per twenty pounds increase in weight. In the work by Hutchinson 950 carcasses weighing 120 to 180 pounds were measured.

Downey, also an Australian worker (1947) outlined a carcass appraisal service designed for the use by farmers who desired to check their breeding and feeding practices. In this system the carcass side is cut at the last rib. This area was selected because not only does it expose the most valuable part of the bacon carcass, but also the latest developing part of the carcass. A part which grows late during development of the animal forms the best index of the state of development of the carcass as a whole. It was stated that carcasses vary much more in the thickness rather than in width of the eye muscle, so the thickness of the eye muscle was selected as the index of lean meat in the carcass.

The results of a study by Aunan and Winters (1952) indicated that a coring device may be used to procure samples of fat and lean tissue for purposes of estimating the relative amounts of fat and lean tissues in a carcass. Of the five positions on the carcass tested, the 5-6 rib sample offers the best index of the lean tissues of the carcass when percentage figures are used. The ratio of fat to lean tissues in the 5-6 rib samples is highly associated with the ratio of fat to lean tissues of the carcass.

Skinner, et al. (1954) found that significant simple correlation coefficients for all possible combinations of fat content of the carcass, fat content of the cuts, and the physical measurements for combined groups of meat, medium, and fat type hogs. The hogs were divided into the above types on the basis of finish and muscling.

The average of all correlations for the fat content of the half carcass and fat content of all the cuts and the physical measurements was 0.681, 0.509, 0.420 for meat, medium and fat types of hogs, respectively. Since correlation coefficients between percent fat and percent water in the various cuts were above -0.917 and highly significant, the water content can be used to determine the fat content of the cuts.

Lu, et al. (1958) investigated means of estimating the percentages of lean, fat, and bone in swine carcasses. It was found that three measurements are needed for the accurate estimation of the factors listed above, namely, the fat percentage of the last rib probe (probes are tissue samples taken by a coring device described previously by Aunan), average backfat thickness, and carcass weight.

Weight of carcass per inch divided by average thickness of backfat is a factor which is easily obtained from simple carcass measurements. This factor lends itself as a possible index for carcass evaluation. The association between this factor and the lean content of the carcass indicates a positive and highly significantly correlated (0.53). Carcass score or value per pound was not associated with the weight per inch of the carcass length divided by the average thickness of backfat.

Pearson, et al. (1956)a investiaged the fat-lean ratio in cross section of the rough loin at the last rib as a possible measure of carcass leanness. These studies indicated that the area of lean at the tenth or last rib was only slightly less reliable than the ratio of fat to lean for estimating cutout values. Pearson, et al. also determined that the degree of association between carcass length and carcass cutout is low with the highest correlation being 0.38. Thus, carcass length may be somewhat over-emphasized in carcass evaluation programs.

Kline and Hazel (1955) compared the relative cross sectional areas of the longissimus dorsi muscle measured at the tenth and last ribs with reference to absolute size, their relationship to each other, and the accuracy of the two locations as measures of total lean in the carcass. The loin area at the last rib averaged .43 square inches greater than that at the tenth rib. There was no significant difference among the correlations between percent lean cuts and loin area at the tenth and last ribs, although the latter area was slightly more closely related to percent loin. These correlations varied from .65 to .74. There was no significant difference among the same or different sides of the carcass.

Whiteman and Whatley (1953) found that the estimates of association with other measures of carcass leanness shown by the two methods of measuring loin lean area (length by width estimate and planimeter reading) indicate that there is not much difference in their relative values. Since the length by width estimate is much more easily obtained, it is thought to be the most useful.

These data indicate that the planimeter method of measuring the ham lean area is more accurate than the estimate obtained from the product of the two dimensional measurements. Measures of the lean area in the butt of the ham contributes little or no additional information about the carcass if the specific gravity, average backfat thickness or loin lean area are known.

Zobrisky (1959) reported that the cross sectional area of the loin eye, cross sectional area of the ham lean and dressing percentage were each significantly correlated with the yield of total lean (0.60, 0.46, 0.36 respectively). The single variable most highly associated with the yield of total lean was the cross sectional area of the loin eye muscle.

The intercorrelations indicated that the ham lean cross sectional area increased with an increase in loin eye cross sectional area, while both variables decreased as carcass length increased. These analysis suggest that in the case of these muscle areas an increase in carcass length was at the expense (a decrease) of the cross sectional area of the loin and ham muscles. No strong relationship was found between carcass length and yield of lean meat.

Sumption, et al. (1959) were of the opinion that longer breeds of hogs have a tendency to have smaller loin eye areas. These workers designed carcass studies to determine if longer hogs have more total loin muscle because of the extra space available for it and the necessity of sufficient muscular support for a longer back. The association between the area and weight of the loin eye muscle shows that cross sectional area is a fair indicator of the weight of the loin eye muscle. An interesting finding is that loin eye muscle weight is a somewhat more accurate predictor of the percentage lean cuts than loin eye area. Measurement of the loin eye area is a simple process, but when used alone is not adequate in estimating lean-fat ratios. These studies revealed a positive correlation between carcass length and percentage of lean cuts (0.45).

Wallace, et al. (1959) conducted two trials, involving a total of 128 pigs of mixed breeding and at four slaughter weights (150, 180, 210, 240 pounds). Dressing percentage based on empty digestive tracts were 73.8, 74.1, 74.8, 75.9 respectively. Backfat thickness was 1.12, 1.26, 1.47, 1.51 inches. Loin eye areas (square inches) measured at the tenth rib were 3.43, 3.85, 4.07, 4.47. Percent lean cuts were 53.77, 53.35, 51.06, 49.33. Barrows gained faster than gilts (P 0.01), however, gilts had less backfat (P 0.01) and significantly larger loin eye muscles, (P 0.01). Variations in loin eye muscle shapes between breeds were observed.

Pearson, et al. (1959) obtained backfat thickness, carcass length, area of loin eye and percent of the various trimmed wholesale cuts for purebred hogs of most of the American breeds. Highly significant differences occurred between some breeds for all traits investigated. Different breeds had a high percentage of certain wholesale cuts such as the loin or ham, whereas others obtained their relative rank by virtue of a high percentage of shoulder or belly. Breed rankings tended to be similar regardless of whether cutouts were calculated on a live or carcass basis. Rankings on area of the loin eye and on lean cuts by breeds showed marked inconsistencies, indicating that loin eye does not closely reflect actual cutouts. Similiarly backfat thickness or carcass length rankings by breeds did not closely parallel similiar rankings for lean or primal cutout.

Zobrisky, et al. (1954) reported that a reasonably accurate estimate of the live hog's value can be determined from the live hog backfat probes or carcass backfat measurements. Backfat measurements were the best indicators of fat yield of the carcass. The following equation was determined to estimate the yield of fat: Yield of fat = 7.27 + .095 times should probe + .088 times hip probe + .205 times ham probe. The cross sectional area of the loin eye gave the highest correlations with the yield of lean. However, all carcass measurements were more highly correlated with the yield of lean than with the yield of fat.

Zobrisky (1959) states that yield of fat can be more accurately measured in the live hog or carcass than the yield of the four lean cuts. Most measurements of fatness measure the subcuteanous fat alone, whereas, most measurements used to evaluate the lean area, in part, measures of fat, lean and bone or combinations of these three components.

Hankins and Ellis (1934) measured thickness of backfat at five specific points. These points were the seventh dorsal vertebra, first dorsal vertebra, seven vertebra below the last lumbar, three and one-half vertebra below the last lumbar, and at the last lumbar vertebra. These measurements were averaged and these values were correlated with the percentages of fat in the edible portion of sixty carcasses. A correlation coefficient of 0.84 was obtained, the standard error being ± .04.

A number of measurements and ratios were studied to determine their value as indices of the percent of fat in the total edible portion of the hog carcass. Thickness of backfat at the seventh dorsal vertebra gave the highest coefficient 0.77 ± .05; width through the shoulder was a close second with a coefficient of 0.74 ± .06.

Ellis and Hankins (1937) reported results of further studies of backfat measurements on 2,681 carcasses. Measurements were taken at the same locations as previously explained. With the possible exception of the shoulder, all measurements show high correlation coefficients with percentage of fat in the edible portion of the carcass.

In recent years average weight largely determined market grade in buying and selling slaughter hogs. Analysis by Wiley, et al. (1951) indicated that average backfat thickness was much more important than carcass weight as a determinant of the percent of lean cuts. The relationship of backfat to other carcass characteristics was also noted. The percent of each of the four lean cuts responded individually in essentially the same manner as the percent of total lean cuts to variations in backfat thickness. The percent of square bellies increased as the average backfat thickness increased. Length of hind leg and body length influenced the percent lean cuts less than backfat thickness.

Work by the North Central Livestock Marketing Research Committee (1952) indicated that backfat thickness held a predominant superiority over other measures of the intact carcass in its ability to predict the percent of the four lean cuts. There was little improvement over the use of backfat thickness alone when body length and backfat thickness were both used to predict the percentage of lean cuts.

Henning and Evans (1953) determined that the backfat thickness at the seventh rib does not correspond accurately with results obtained when the three standard measurements are averaged. Over 53 percent of the carcasses studied had a backfat thickness at the seventh rib which varied .12 inches or more than the average of three measurements. In addition, the effect of human errors in measurement of backfat thickness would be less important when three measurements are averaged, as compared to only one measurement in determining backfat thickness.

Results of a study by Engelman, et al. (1950) inferred that backfat thickness was the primary determinant of carcass merit and that other factors did not improve the relationship enough to warrant their detailed treatment in correlation procedures.

Cummings and Winters (1951) reported high correlations between the ratio of backfat thickness to length of carcass and the yield of five primal cuts and the index of fat cuts (-0.67 and 0.76 respectively). The correlations between average backfat thickness and the yield of primal cuts and the index of fat cuts were -0.65 and 0.75 respectively. The ratio of backfat thickness to length of carcass was called the T factor. An increase of one inch in the average backfat thickness indicated a decrease of five percent in the yield of the five primal cuts and an increase of seven percent in the index of fat cuts.

It was suggested that the T factor rather than backfat thickness alone be used for predictive purposes because carcass value is also influenced by its length. The correlations between length of carcass and either percentage yields of the five primal cuts or fat cuts, although significant were not high.

Yields of the five primal cuts and fat cuts were highly correlated with chilled carcass weight (-0.38 and 0.36 respectively). Therefore, adjustments must be made when comparisons are to be made between carcasses of different weights.

Henning and Evans (1953) correlated seventeen factors with the percent of the four lean cuts. These factors consist of physical measurements and percentage yields of the carcass. Average backfat thickness was the most important single factor influencing the percent lean cuts, followed by hind leg length and body length. These three factors together explained nearly 72 percent of the variation in the percent of the four lean cuts, assuming all other things equal.

Bruner (1959) reported that the weight of the skinned ham and the trimmed loin and the area of the loin eye in both barrows and gilts were more closely correlated with lean cuts than either carcass length or backfat, in data secured through the Ohio Swine Improvement Program.

Correlations between characteristics were:

		Range	
		barrows	gilts
pounds skinned ham———	pounds lean cuts	.79 - .88	.83 - .89
pounds trimmed loin———	" " "	.74 - .86	.67 - .83
loin eye area———————	" " "	.61 - .71	.56 - .76
backfat thickness————	" " "	-.13 - (-.51)	-.11 - (-.47)
carcass length——————	" " "	-.02 - .27	-.15 - .33

Pearson, et al. (1958)a found that simple cut indices involving a minimum number of weights and adapted to large scale usage may be utilized in evaluating swine carcasses. A comparison of loin index (the percentage of trimmed loin in relation to rough loin) and backfat thickness as measures of percent lean cuts (carcass basis) justifies the conclusion that loin index more accurately reflects percent lean cuts. Percent skinned ham and percent New York shoulder indicates cutout nearly as well as the various loin indices. Percent trimmed belly was a poor indicator of all lean cutouts and loin lean area.

It was postulated by Pearson, et al. that the use of primal cuts in selection programs may retard progress in development of hogs producing a high proportion of lean meat due to the confounding influence of the belly which is essentially a fat cut.

Subsequent data presented by Pearson, et al. (1958)b show that carcass length and percent loin are positively correlated, yet variation in length accounted for only 17 to 18 percent of the variability in percent loin. Carcass length did not appear to influence percent belly, percent ham, or percent New York shoulder, which explains the low degree of relationship between carcass length and lean cutouts. It was apparent that length alone does not increase the percent belly. It is postulated that increases in percent belly are more likely to be due to an increase in thickness than an increase in length.

Studies by Whiley, et al. (1951) indicated that among lean carcasses within various weight groups, when either the body length or hind leg length was increased, the average carcass cutout value tended to decrease. However, among the fat carcasses of all weights studied neither body length nor hind leg length appeared to have any separate effect upon the average cutout value. These studies indicated that neither body length nor hind leg length merits much consideration in carcass grading.

The use of specific gravity has become a valuable tool in the evaluation of pork carcasses in recent years. Brown, et al. (1951) reported that correlations of carcass specific gravity with area of loin eye, percent primal cuts, percent lean cuts, and carcass length, were positive and highly significant (correlations were .46, .68, .84, and .56 respectively). Highly significant negative correlations were found between carcass specific gravity and average backfat thickness (-.68), percent fat cuts (-.78), and chilled carcass (-.42). The correlations calculated in this study indicate the fat or lean content of the carcass may be as accurately estimated by specific gravity as by the percent fat cuts or percent lean cuts.

In one group of swine carcasses, Whiteman, et al. (1953) observed that carcass specific gravity was significantly more highly correlated with other measures of carcass leanness than was average backfat thickness. In another group specific gravity was also more highly associated, though not significantly, with other measures of carcass leanness than average backfat thickness.

It has been reported by Pearson, et al. (1956)b that specific gravity of the entire carcass was more highly associated with carcass fatness than average backfat thickness. Studies were conducted to determine if a single untrimmed cut could be used as an index of the composition of the entire carcass. It was found that the specific gravity of the regular ham, loin, or shoulder was closely associated with specific gravity of the entire carcass. The untrimmed ham was a more reliable index of the specific gravity of the entire carcass than either the rough loin or untrimmed shoulder. Specific gravity of either the entire carcass or the ham proved to be superior to backfat thickness as a measure of carcass leanness. These studies also show that loin eye area averaged .51 square inches more at the last rib than at the tenth rib.

Price, et al. (1957) found that loin lean area at the tenth rib and specific gravity of the regular ham showed a very similar relationship to percent lean cuts. Although the two loin lean area measurements (tenth rib and last rib), were closely related (.82), the area measured at the tenth rib was more highly correlated with specific gravity and cutout values than the area at the last rib. This indicated that loin lean area at the tenth rib was a more reliable measure of leanness than the corresponding area at the last rib.

Carcass length showed no significant relationship with cutout. Carcass length combined with backfat thickness or live probe gave little advantage over the use of backfat thickness or live probe alone in determining carcass cutout.

It is believed that there is considerable error involved in repeated carcass measurements made by single observers and by different observers. The data concerning the level of repeatability either within or between observers is rather limited. The level of repeatability will obviously differ between the various characteristics that are measured.

Hetzer, et al. (1950) calculated the repeatability of single measurements on the same live hog. The repeatability between single measurements of body length by each of two men was .724 or 92.4 percent. The differences between the measurements of two men were too small in most cases to be of any importance.

Repeatability values ranged from .558 for height at the shoulders to .767 for width of middle. Repeatability values estimated on the basis of averages of four measurements were found to be considerably higher than those based on only one measurement.

Stull (1953) developed a technique to facilitate an easier and faster method to collect loin eye measurements. The equipment consisted of a Kodak 35 camera with flash attachment. A lens attachment and adapter ring were required as the photographs were taken at a focal range of 24 inches. A frame was utilized to insure a constant focal range.

The accuracy of the photographic method was checked against planimeter measurements made from original tracings. A correlation coefficient of .982 between the two methods indicates that the photographic method can be used with confidence.

Black (1959) reported a new method for obtaining loin eye data that basically involves photographing loin eyes with a special but simple apparatus. Color transparencies of the loin eyes are then projected for measurement with a polar planimeter. Normally variation exists between measurements of the same loin eye tracings obtained by different individuals, but there is little variation using the method proposed by Black. The slides when projected, are enlarged so that the loin eye is four times its actual size. This facilitates accuracy in measuring. The final reading is divided by four.

Bodwell, et al. (1959) stated that the cross sectional area of the eye muscle of beef carcasses may be accurately measured by tracing the boundary and measuring the tracing with a planimeter. Taking a single area measurement from each of duplicate tracings increases the accuracy by some 30 percent. This area may be estimated by superimposing a grid on the tracing and counting squares. This method is approximately 25 percent less accurate than the planimeter method. Estimating area by combinations of linear measurements, such as maximum width times maximum depth of the cross sectional area, predicts true area with insufficient accuracy for experimental use.

Deans, et al. (1959) obtained results from photometric measurement of carcass cross sectional areas using a 4 x 5 Graflex Crown Graphic camera equipped with a Polaroid Land back and using type 46L Polaroid projection transparencies. For expediency and accuracy, camera to subject distances and subject location have been fixed and a scale mounted in plane with the surface to be photographed. A standard slide projector is used in combination with a mirrored surface placed at 45 degrees with respect to the horizontal projector axis. Thus, the projected image is changed 90 degrees and projected to the under side of a plate glass surface mounted in a horizontal plane. Measurements are made using a planimeter directly on acetate film placed on the top surface of the plate glass.

Studies have shown accuracy of reproduction to within 0.5 mm. of actual block measurements. A study of reproducibility on sample lamb loin cross sections has shown standard deviations in longissimus dorsi cross sectional area of .06 square inches and of .07 mm. in external fat thickness with the photometric method as compared to standard deviations of .24 square inches in area and .275 mm. in external fat thickness using standard tracing techniques.

Lasley and Kline (1957) determined the magnitude of cutting errors for various carcass traits using 222 barrow carcasses. The coefficients of variation are largest for those traits produced by several distinct cutting steps. For example, Boston butt, loin, picnic, and belly have relatively large errors, while carcass length and backfat thickness which are measured on opposite surfaces of a single cut have relatively small errors. The ham has relatively less cutting error than any of the other wholesale cuts. About one-half of the cutting variation for lean cuts reflects lack of precision in cutting the loin. The left side averaged heavier and yielded heavier loin, ham, picnic, lean cuts, and primal cuts but lighter belly and Boston butt. The coefficient of variation for loin eye area was relatively large yet the observed repeatability (correlation of 185 at the 10th rib and .90 at the last rib) between sides is high indicating that cutting errors do not seriously limit ability to discrimate between carcasses for this trait.

Self, et al. (1957) conducted a study involving 584 carcasses with weights ranging from 126 to 167 pounds in an attempt to determine the association of carcass grade and weight with the quality and composition of certain pork cuts. Each of the USDA swine carcass grades except cull was represented in each of seven weight groups. The average backfat thickness for barrow and gilt carcasses was 1.66 inches and 1.65 inches respectively. Average carcass length for barrows and gilts was 29.0 inches and 29.2 inches respectively. Analysis of variance indicated no significant difference between the average 48.5 percent lean cut yield of barrows and the 48.6 percent mean yield of gilts. Each grade differed significantly from all other grades in respect to lean cut yield. Highly significant differences existed among the carcass grades in percent ham and percent loin, but there was no significant difference among the weight groups in respect to these factors. The Medium grade carcasses had the highest percent ham of any of the four grade groups studied (20.2 percent) and No. 3 the lowest (17.2 percent). The US No. 1, US No. 2, and US No. 3 grades yielded 19.3, 18.3, 17.2 percent of ham and had 1.5, 1.78 and 2.05 inches of backfat respectively. The loin percentages were 16.0, 15.4, 14.6, and 13.6 percent for the Medium, US No. 1, US No. 2, and US No. 3 grades respectively. Average loin eye area for barrow carcasses, measured at the 10th rib was 3.49 square inches. Average loin eye area for gilts, 3.81 square inches, was significantly larger than the loin eye area of barrows.

EXPERIMENTAL METHODS

Slaughter Procedure

The data in this study were obtained from 66 purebred barrows from the Kansas Swine Testing Station. The breeds represented were Hampshire, Duroc, Poland China, Yorkshire, Landrace, Berkshire, and Tamworth. The barrows were weighed at the testing station and delivered to the meat laboratory approximately twelve hours before slaughter. An effort was made to slaughter the barrows at a weight as near to 200 pounds as possible by delivering them to the laboratory at a weight of between 205 and 210 pounds. The usual twelve hour shrink without water or feed was from 5 to 10 pounds.

All hogs were dressed essentially packer style, head off, leaf fat removed and hams unfaced. Hot carcass weight was recorded. Digestive tract weights were taken immediately after eviserating and again after removal of the contents of the tract. The loss in weight upon removal of digestive tract contents was subtracted from slaughter weight to determine net body weight or empty body weight. (Slaughter data collection form is included in Appendix B)

Carcass Measurement

The carcasses were cut approximately 24 hours after slaughter. The carcasses were chilled at temperature of 30 to 34 degrees. Before cutting, each side of the carcass was weighed and cooler shrink was calculated. Before the carcass was removed from the rail the ribs were counted on each side. Backfat thickness and carcass length were also measured on both sides. Length of carcass was measured from the anterior edge of the aitch bone to the anterior edge of the first rib at a point adjacent to the vertebra. Backfat thickness was measured opposite the first rib, 10th rib and last lumbar vertebra and averaged. Skin thickness was included in the backfat measurement. All linear measurements were recorded to the nearest 1/10 inch. After the carcass was removed from the rail and placed on the cutting table length was again measured using the same reference points as above.

Cutting Procedure

The cutting procedures used follow those described by the pork evaluation committee at the 1952 Reciprocal Meat Conference with the following exceptions. The rough shoulder was removed at 1 1/2 ribs. The ham was removed at a point halfway between the anterior point of the aitch bone and the first sacral vertebra and at a right angle to the long axis of the ham. The ham was skinned to 1/4 inch of fat. The rough loin was divided into three sections by cutting at a point immediately posterior to the junction of the 10th rib with the thoracic vertebra and immediately posterior to the last rib. The exposed surface of the longissimus dorsi muscle on each end of the center section of the loin was traced independently, on acetate paper by two individuals. Tracings were made on both sides of the carcass. The weight of each trimmed wholesale cut, fat trim, lean trim and waste were recorded for each side. Tracings of the cross sectional area of the longissimus dorsi were measured with a compensating polar planimeter. All measurements were made by the same individual. The accuracy of the measurement was ± .02 square inch. (Carcass data collection form is included in Appendix C)

Analysis of Data

The percentage of all wholesale cuts, lean and fat trim, and leaf fat was calculated on cold carcass weight basis for each side as well as the entire carcass. Simple correlation coefficients were calculated between all possible combinations of the following measurements and percentage components of the carcasses.

Live weight
Cold dressed weight
Net body weight
Dressing percentage (net body weight basis)
Length (hanging)
Length (table)
Number of ribs
Average backfat thickness
" " " (right side)
" " " (left side)

Loin eye area (last rib, right))	
" " " (last rib, left))	1st observer
" " " (ave. left and right))	and
" " " (10th rib right))	2nd observer
" " " (10th rib left))	
" " " (ave. left and right))	

Percent lean cuts (live weight basis)
" " " (cold dressed weight basis)
" " " (net body weight basis)
" " " (cold dressed weight basis, left side)
" " " (" " " " , right side)
Regular ham
Trimmed ham
Trimmed loin
Total fat trim
Leaf fat

Simple correlation coefficients were also calculated between picnic and average backfat thickness and Boston butt and average backfat thickness.

Methods for determining simple correlation coefficients were in accordance with those described by Snedecor. (A complete correlation table is included in Appendix A)

RESULTS AND DISCUSSION

Data from the 66 carcasses studied can be summarized as a group as follows: Average slaughter weight was 198 pounds, percent lean cuts (cold carcass weight basis) averaged 47.95 with a range of 42.1 to 55.22, average cross sectional area of the longissmus dorsi muscle was 3.56 square inches with a range of 2.25 to 5.79 square inches. Average backfat thickness was 1.65 inches. Divided into the USDA swine carcass grades, there were 32 No. 1's, 24 No. 2's, and 10 No. 3's.

The averages and ranges by grades of backfat thickness, carcass length, loin eye area at the 10th and last rib, percent lean cuts, percent fat trim, percent skinned ham, and percent trimmed loin are presented in Table 1. Differences between US No. 1 and 2 carcasses are more clearly defined than differences between US No. 2 and 3 carcasses. (Weight and measurement guides to grades for barrow and gilt carcasses are included in Appendix D). This may be explained by the small number of US No. 3's involved and the fact that most of the US No. 3's were in the thinner half of the grade. Only three barrows in the study had an average backfat measurement that exceeded two inches.

The most notable difference between the grades is backfat thickness. This is understandable from the fact that backfat thickness is the primary factor used to determine grade. Differences in carcass length are not as clear cut as differences in backfat thickness. There is considerable overlaping between grades in respect to length. Although it has been shown by Wiley, et al. (1951), Pearson, et al. (1958)b, and Zobrisky (1959) that excessive length is not of particular importance in determining yield of lean cuts, several of the carcasses studied were upgraded because length exceeded thirty inches.

The difference in percent lean cuts is much greater between US No. 1 and No. 2 barrows than that between US No. 2's and 3's. This difference and lack of difference is probably due to several exceptionally high yields of lean cuts among the carcasses in the No. 2 grade and the small sample of No. 3 carcasses.

The average percent total fat trim is closely associated with backfat thickness.

Differences between cross sectional area of the loin eye at the 10th rib and at the last rib vary by approximately the same amount in each grade with the larger area at the last rib in all cases. These data indicate that on the average there is about one-half square inch difference between cross sectional area of the loin eye measured at the last rib and loin eye area measured at the tenth rib regardless of grade. These observations are in agreement with Kline and Hazel (1955) and Pearson, et al. (1956)a. In this

Table 1. The average and range of eight carcass measurements by carcass grade.

	No. 1		No. 2		No. 3	
	Average	Range	Average	Range	Average	Range
Backfat thickness	1.48	1.28 - 1.60	1.74	1.62 - 1.95	1.97	1.91 - 2.17
Length	29.41	27.85 - 31.75	28.86	27.10 - 30.60	28.72	27.05 - 29.75
Loineye Area, 10th	3.75	2.74 - 5.79	3.43	2.25 - 4.12	3.27	2.87 - 3.72
Loineye Area, Last	4.27	3.08 - 6.83	3.80	2.51 - 4.56	3.64	3.25 - 4.45
% Lean cuts	49.48	46.30 - 55.22	46.52	42.10 - 50.23	46.50	44.39 - 48.62
% Total fat trim	18.75	15.26 - 21.89	21.61	17.96 - 25.58	22.15	19.38 - 24.54
% skinned ham	18.34	16.21 - 20.48	17.37	14.75 - 18.91	17.34	16.69 - 18.46
% loin	16.21	14.19 - 18.76	14.91	13.42 - 17.70	14.84	13.20 - 16.97

study loin eye area was found to decrease as backfat thickness increased. Apparently there is a relationship between area of the loin eye and backfat thickness. If this is true for all weight ranges, loin eye area may be a tangible factor for use in selecting breeding stock for less fat.

The ham represents two to three percent more of the chilled carcass than the loin and since this appears to be true for all grades, the ham may be a more reliable index of lean cuts than the loin.

The relationship of lean cuts to other carcass factors is presented in Table 2. The correlations between lean cuts and the following factors are all highly significant: percent regular ham, percent trimmed ham, percent trimmed loin, average backfat thickness, average loin eye area at the 10th rib, and average loin eye area at the last rib. Correlations of percent lean cuts of either the right or left side with regular ham, trimmed ham, and trimmed loin, closely parallel the correlations of percent lean cuts expressed as percent of the chilled carcass with these same factors. These correlations indicate that an accurate determination of lean cuts can be obtained by cutting only one side of the carcass. The high correlation (.79) between trimmed ham and percent lean cuts calculated on cold carcass weight suggests that percent trimmed ham alone may be used to indicate the lean cut yield of a carcass. Similar results concerning the relationship between trimmed ham and percent lean cuts have been reported by Pearson, et al. (1958) and Bruner (1959).

A strong relationship exists between percent lean cuts and loin eye area. These data indicate that the loin eye area measured at the last rib is a somewhat better indicator of percent lean cuts (.67) than loin eye area measured at the 10th rib (.60). Kline and Hazel (1955) reported similar

Table 2. Correlation coefficients between lean cuts and some other carcass characteristics.

	% lean cuts (live basis)	% lean cuts (carcass basis)	% lean cuts (NBW basis)	% lean cuts (left)	% lean cuts (right)	% Regular ham	Trimmed ham	% Trimmed Loin	Average backfat thickness	Average Loin eye area 10th rib	Average Loin eye area last rib
% lean cuts (live basis)		.93	.96	.88	.87	.49	.75	.71	-.59	.63	.70
% lean cuts (carcass basis)			.91	.94	.94	.52	.79	.76	-.58	.61	.68
% lean cuts (NBW basis)				.85	.85	.41	.68	.72	-.60	.59	.64
% lean cuts (left)					.80	.54	.77	.68	-.51	.55	.64
% lean cuts (right)						.50	.78	.76	-.62	.64	.69
% Regular Ham							.87	.90	-.18	.56	.58
% Trimmed Ham								.43	-.42	.71	.76
% Trimmed Loin									-.51	.48	.54
Average Backfat										-.33	-.34
Average loineye Area, 10th Rib											.90

correlations between percent lean cuts and loin eye area measured at the 10th rib and last rib. Loin eye area measured at the last rib also is more highly correlated with percent regular ham, percent skinned ham, and percent trimmed loin than is loin eye area measured at the 10th rib. High correlations between percent trimmed ham and loin eye area, (.71 and .76 at the 10th and last rib respectively) again emphasize the fact that the skinned ham is an excellent indicator of carcass muscling. It is interesting to note that the cross sectional area of the longissmus dorsi muscle is more highly correlated with the percentage skinned ham than with the trimmed loin of which the longissmus dorsi is a major component. The correlation between cross sectional area of the loin eye at the 10th rib and last rib (.90) is in agreement with the findings of Price, et al. (1957).

These data suggest that cross sectional area of the longissmus dorsi muscle should be measured at the last rib rather than at the tenth rib.

In general only significant correlations in Table 2 and subsequent tables are discussed.

With the exception of one carcass, the carcass length was greater when measured on the rail than when measured on the table. The difference in length varied from 0 to one inch between the measurement taken on the rail and the measurement taken on the table. The largest differences were observed in the softest carcasses. In a few cases the USDA carcass grade (based on length and fatback thickness) could have been changed by merely removing the carcass from the rail and measuring the length of the carcass on the table. Carcass length measured on the table was more highly correlated with number of ribs (.52) than length hanging (.43), Table 3. This may be partially explained by the fact that carcasses with a larger number of ribs

Table 3. Correlation coefficients of length factors and number of ribs with same carcass characteristics.

	Length (Hanging)	Length (on table)	No. Ribs	% lean cuts (carcass basis)	% trimmed ham	% trimmed loin	Average backfat thickness	Loin eye area 10th rib
Length (hanging)		.96	.43	.24	-.06	.38	-.25	-.05
Length (on table)			.52	.13	-.21	.33	-.21	-.16
No. of ribs					-.22	.16	.04	-.24

and hence smaller intercostal spaces tend to contract less when laid on a table than those carcasses with fewer ribs. Number of ribs varied from 14 to 16 with three carcasses having one more rib on one side than the other. Correlations between length measured on the table and the other factors studied are similar to the correlations between carcass length measured on the rail and these same factors. The measurement made on the table is influenced by the firmness of the carcass, number of ribs, and the position in which the carcass is laid. Therefore the measurement taken on the table is subject to considerable error. Thus, carcass length should be measured while the carcass is suspended from the rail.

The only other highly significant correlation in Table 3 is length with percentage trimmed loin (.38). Pearson, et al. (1956) reported an identical correlation between carcass length and percent trimmed loin. It might be noted that length was not significantly correlated with loin eye area although the negative correlation (-.24) between number of ribs and loin eye area approaches significance at the 5 percent level. Negative correlations approaching significance were also obtained between percent trimmed ham and length on the table (-.21) and also number of ribs (-.22). These observations tend to indicate that emphasis on length could result in a trend toward what is commonly known as a meatless type carcass.

The only other correlation concerning length that is noteworthy is that between length hanging and average backfat thickness. This correlation (-.25) is significant at the .05 level.

Correlations between carcass length and other carcass characteristics are low.

Average backfat thickness correlated with total fat trim gives the highest positive correlation obtained from any single factor related to fat, Table 4. Correlations of -.70, -.69, and -.88 between total fat trim and percent trimmed ham, percent trimmed loin and percent lean cuts respectively were the highest negative correlations related to fatness. Average backfat thickness is probably the most commonly used indicator of the composition of swine carcasses. The highly significant correlation coefficient of .69 between average backfat thickness and total fat trim indicates that average backfat thickness may be used with confidence to predict the fat yield of swine carcasses. Highly significant negative correlations of -.59, -.58, and -.61 were obtained between average backfat thickness and percent lean cuts calculated as percent of live weight, chilled carcass weight, and net body weight respectively, Table 2. These data indicate that average backfat thickness is not as reliable an indicator of lean cuts in the swine carcass as it is an indicator of fat trim. This conclusion is in agreement with Zobrisky (1959) who stated that yield of fat can be more accurately measured in the live hog or carcass than the yield of the four lean cuts.

The correlation between average backfat thickness and percent regular ham is considerably lower than the correlation between average backfat thickness and percent trimmed ham. Although both correlations are negative the correlation between average backfat thickness and regular ham is non-significant (-.18) while the correlation between average backfat thickness and trimmed ham is highly significant (-.42). There is undoubtedly a high degree of relationship between backfat thickness and fat trim from the ham because the ham fat is merely a continuation of the subcutaneous fat deposit. The correlation between percent trimmed loin and average backfat thickness is -.51 which is somewhat higher than the correlation between percent trimmed ham

Table 4. Correlation coefficients between various fat measurements and other carcass factors.

	Average backfat thickness	Average backfat (left)	Average backfat (right)	% total fat trim	% left fat	% regular ham	% trimmed ham	% trimmed loin	% lean cuts (carcass basis)	Picnic
Average backfat thickness		.99	.98	.69	.15	-.18	-.42	-.51	-.58	-.25 butt -.37
Average backfat (left)			.94	.70	.14	-.18	-.41	-.50	-.58	
Average backfat (right)				.65	.14	-.19	-.40	-.49	-.55	
Total fat trim					.19	-.44	-.70	-.69	-.88	
% leaf fat						-.19	-.18	-.09	-.22	

and average backfat thickness. This indicates that fat thickness influences the yield of trimmed loin to a greater extent than the yield of trimmed ham. Pearson, et al. (1958)a reported similar findings in this regard. Pearson, et al. (1958)a reported similar findings in this regard. Pearson, et al. also stated that the ratio of trimmed loin to rough loin more accurately reflected percent lean cuts than average backfat thickness. Correlations between average backfat thickness and picnic and average backfat thickness and Boston butt, -.25 and -.37 respectively, are considerably lower than correlations between average backfat thickness and the more valuable ham and loin. These facts indicate that as backfat thickness increases, not only does the yield of total lean cuts decrease, but the relative proportion of the more valuable cuts (ham and loin) to the less desirable cuts of the shoulder decreases. The relative increase in proportion of the lean cuts from the shoulder is probably due to the increased inter-muscular fat deposits in this area of the overfinished carcass.

No highly significant correlations were observed between percent leaf fat and the other 25 factors studied. Apparently the deposition of leaf fat is independent of other fat deposits. Leaf fat probably is more closely related to visceral factors than other carcass characteristics.

In carcass evaluation where it is impossible or inconvenient to cut both sides of a carcass, some question has been raised regarding the accuracy of data obtained from cutting a single side of a carcass. This study offered an opportunity to compare measurements made on one side, either the left or right side, with those of the entire carcass. Correlations were determined between percent lean cuts for the entire carcass, those from the left side, and those from the right side with numerous other carcass measurements. These data are presented in Table 5.

The correlation between the percent lean cuts of the left side with the percent lean cuts of the right side (.80) is somewhat lower than the correlation of either the right or the left side with total percent lean cuts of the carcass (.94 and .95 respectively). The lower correlation between percent lean cuts of the left and right side is probably due to variation in the technique of different individuals involved in cutting the carcasses. If both sides of all carcasses were cut by the same individual a higher correlation between sides would probably be observed. The high correlation between percent lean cuts of the carcass and percent lean cuts of the right side or the left side of the carcass indicates that in certain research areas where extreme accuracy is not required, and in carcass competition, one side of the carcass will furnish adequate information on percent lean cuts. These findings are not in complete agreement with those of Lasley and Kline (1957) who found that the left side averaged heavier and yielded heavier loin, ham, picnic, lean cuts and primal cuts than the right side.

Average loin eye area (measured at the 10th rib) of the right and left sides was highly significantly correlated with the loin eye area of a single side, either the right or left. The correlation was .98 in both instances. Correlations between loin eye area and other factors studied are very similar, regardless of whether an average of both sides is used to determine the loin eye area or whether the right or left side is used to determine the loin eye area.

The correlations between average backfat thickness involving both sides of the carcass and average backfat thickness of the right and left sides (.98 and .99 respectively) of the carcass are of the same magnitude as the

Table 5. Correlation coefficients between some measurements of the right and left sides of the carcass.

	% lean cuts (carcass basis)	% lean cuts (left)	% lean cuts (right)	Ave. loin eye area 10th rib	Loin eye area 10th rib left	Loin eye area 10th rib right	Average backfat thickness both sides	Average backfat thickness left	Average backfat thickness right
% lean cuts (carcass basis)		.94	.94	.61	.59	.60	-.58	-.58	-.55
% lean cuts (left)			.80	.55	.53	.54	-.51	-.51	-.49
% lean cuts (right)				.64	.62	.61	-.62	-.62	-.59
Ave. loin eye area, 10th rib					.98	.98	-.33	-.30	-.33
Loin eye area 10th rib, left						.92	-.32	-.29	-.32
Loin eye area 10th rib, right							-.32	-.30	-.32
Average backfat thickness, both sides								.99	.98
Average backfat thickness, left									.94
Average backfat thickness, right									

respective correlations concerning loin eye area. A correlation of .94 between average backfat thickness of right and left sides is the highest correlation observed between sides of the three factors studied.

These data indicate that only one side, either the right or left may be used with confidence for determining carcass value whether it be for research or carcass competition. It should be emphasized that, where one side is used to furnish carcass information it is imperative that extreme care is exercised in splitting the carcass.

In a large proportion of meat research work and in carcass competition tissue areas or shapes are reproduced by tracing the outline of the tissue on transparent paper to facilitate measuring. Stull (1953), Black (1959), and Deans, et al. (1959) reported photometric methods of reproducing loin eye areas. The most common method of measuring loin eye area is with a compensating polar planimeter. Bodwell, et al. (1959) stated that the cross sectional area of the eye muscle of beef carcasses may be accurately measured by tracing the boundry of the muscle and measuring the tracing with a planimeter. Quite frequently, when time is limited, it would be convenient if two or more individuals could be utilized in the tracing procedure. The data presented in Table 6 indicate that the same carcass tissue area, usually backfat thickness or loin eye area, can be accurately reproduced for research purposes by any individual who has the proper experience and knowledge of anatomy to distinguish the specific tissues being reproduced.

The underlined correlation coefficients in Table 6 indicate the relationship between two tracings of the same area made by two different individuals. The variation in these correlations, regardless of the location of the area traced, is between .96 and .97.

Table 6. Correlation coefficients between two observers for loin eye muscle measurements.

1st observer	2nd observer					
	Last Rib R	Last Rib L	Last Rib Ave.	10th Rib R	10th Rib L	10th Rib Ave.
Last Rib, Right	.97	.91	.94	.90	.87	.90
Last Rib, Left	.90	.97	.94	.86	.85	.87
Last Rib, Ave.	.96	.96	.96	.90	.88	.90
10th Rib, Right	.88	.85	.88	.96	.90	.94
10th Rib, Left	.85	.84	.86	.90	.96	.93
10th Rib, Ave.	.88	.86	.89	.95	.94	.96

The number of very high correlations presented in Table 6 emphasizes the fact that tracings of cross sectional areas of the longissimus dorsi muscle have a high degree of relationship regardless of whether the tracing is made at the 10th rib or the last rib, on one side or both sides even when two or more individuals are involved in tracing the areas.

SUMMARY

A study was made to determine the relative value of certain carcass characteristics in determining the value of swine carcasses. Some interrelationships between these characteristics were also studied.

Carcasses of 66 barrows from the Kansas Swine Testing Station were utilized in this experiment. By USDA grade, there were 32 No. 1's, 24 No. 2's, and 10 No. 3's. Average percent lean cuts was 47.95 percent, average cross sectional loin eye area was 3.56 square inches, and average backfat thickness was 1.65 inches. The primary factors considered were carcass length, backfat thickness, loin eye area, number of ribs, percent lean cuts, percent fat trim, and percent leaf fat. Simple correlation coefficients were determined for all possible combinations of these factors.

A highly significant correlation was found between percent lean cuts and percent skinned ham (.79). This high correlation suggests that percent skinned ham alone may be used as an indicator of lean cuts or carcass value. Percent lean cuts were also found to be highly correlated with percent trimmed loin (.76), and average loin eye area measured at the last rib and 10th rib (.67 and .60 respectively). These data indicate that loin eye area measured at the last rib is a somewhat better indicator of percent lean cuts than loin eye area measured at the 10th rib. Loin eye area measured at the last rib

is also more highly correlated with percent regular ham, percent skinned ham, and percent trimmed loin than loin eye area measured at the 10th rib. These correlations suggest that cross sectional area of the loin eye should be measured at the last rib rather than at the 10th rib.

The correlation between number of ribs and carcass length was highly significant. Carcass length was measured while the carcass was suspended from the rail and after it was placed on the cutting table. It was concluded that carcass length should be measured while the carcass was suspended because the measurement made on the table was subject to considerable error. Carcass length had little influence on the yield of lean cuts.

Although highly significant negative correlations were determined between average backfat thickness and percent lean cuts, average backfat thickness was found to be a more reliable indicator of fat yield than lean yield. The data indicate that as backfat thickness increases, not only does the yield of total lean cuts decrease, but the relative proportion of the more valuable cuts (ham and loin) to the less desirable lean cuts of the shoulder decreases.

A poor relationship was noted between leaf fat and the other factors studied.

Highly significant correlations between characteristics of the complete carcass and the same characteristics of a single side of the carcass indicate that one side of the carcass, either the right or left, may be used with confidence to determine the carcass value.

The repeatability of tracings of the cross sectional loin eye area made by two individuals was studied. The range of correlations between tracings of the same area made by two individuals was from .96 to .97. The highly significant correlations obtained from these data emphasize the fact that two or more persons can be utilised in any situation where tracings of carcass tissue areas are being made without introducing a source of error.

ACKNOWLEDGMENT

The author wishes to express his appreciation to Professor D. L. Mackintosh, major instructor, and Dr. F. A. Merkel for their invaluable assistance and advice in the planning and completion of this study and in the preparation of the manuscript.

The author also wishes to thank G. F. Krause of the Department of Statistics for his help in the analysis of the data, and the many members of the Department of Animal Husbandry who participated in the collection of data.

LITERATURE CITED

Aunan, W. J., and L. M. Winters.
A study of the variations of muscle fat and bone of swine carcasses. J. Animal Sci. 8:182-190. 1949.

Aunan, W. J., and L. M. Winters.
A method for measuring the proportion of fat and lean tissue in swine carcasses. J. Animal Sci. 11:319-325. 1952.

Bennett, J. A., and J. H. Coles.
A comparative study of certain performance and carcass characteristics of Yorkshire barrows and gilts. Sci. Agr. 26:265-270. 1946.

Black, N.
A new method for obtaining loin eye data. National Hog Farmer. 4 No. 10:40. 1959.

Bodwell, C. E., G. Harrington and R. W. Pomeroy.
A note on the measurement of eye muscle area in beef carcasses. Animal Prod. 1 part 2:97-101. 1959.

Brown, C. J., J. C. Hillier, and J. A. Whatley.
Specific gravity as a measure of the fat content of the pork carcass. J. Animal Sci. 10:97-103. 1951.

Bruner, W. H.
Ham, loin best lean cut indicators. National Hog Farmer. 4 No. 10:32. 1959.

Bull, S. and J. H. Longwell.
Type in swine as related to quality of pork. Ill. Agr. Exp. Sta. Bul. 322:392-490. 1929.

Cummings, J. N., and L. M. Winters.
A study of factors related to carcass yields in swine. Univ. Minn. Agr. Exp. Sta. Bul. 195. 1951.

Deans, R. J., L. J. Bratzler and D. C. Price.
The photometric measurement of carcass cross sectional areas directly from projected polaroid transparencies. J. Animal Sci. 18:1485. 1959. (Abstract)

Downey, L. A.
Pig carcass appraisal. Jour. Agr., Victoria, Australia. 45:354-359. 1947.

Ellis, N. R., and O. G. Hankins.
Some relationships between backfat measurements and weight, firmness and other characteristics of hog carcasses. Am. Soc. Animal Prod. Proc. 30:242-246. 1937.

Engelman, G., A. A. Dowell, E. F. Ferrin and P. A. Anderson.
Marketing slaughter hogs by carcass weight and grade. Univ. Minn. Agr. Exp. Sta. Bul. 187. 1950.

Hammond, J. and G. N. Murry.
The body proportions of different breeds of bacon pigs. Jour. Agr. Sci. 27:394-431. 1937.

Hankins, O. G.
A study of carcass characteristics in relation to type of hog. Am. Soc. Animal Prod. Proc. 33:284-289. 1940.

Hankins, O. G.
Relation between type in hogs and the plumpness of their hams. Am. Soc. Animal Prod. Proc. 27:120-123. 1934.

Hankins, O. G., and N. R. Ellis.
Fat in relation to quantity and quality factors of meat animal carcasses. Am. Soc. Animal Prod. Proc. 32:314-319. 1939.

Hankins, O. G., and N. R. Ellis.
A study of ham composition with special reference to type of hog. Am. Soc. Animal Prod. Proc. 28:111-116. 1935.

Hankins, O. G., and N. R. Ellis.
Physical characteristics of hog carcasses as measures of fatness. Jour. Agr. Res. 48:257-264. 1934.

Henning, G. F., and M. B. Evans.
Market hogs can be accurately graded. Ohio Agr. Exp. Sta. Res. Bul. 728, 1953.

Hetzer, H. O., O. G. Hankins, J. X. King and J. H. Zeller.
The relationship between certain body measurements and carcass characteristics in swine. J. Animal Sci. 9:37-47. 1950.

Hutchinson, K. J.
Observations on the use of the Hammond system of pig carcass appraisal in Queensland Australia. Queensland Jour. Agr. Sci. 8:106-119. 1951.

Kline, E. A., and L. N. Hazel.
Loin eye area at tenth and last rib as related to leanness of pork carcasses. J. Animal Sci. 14:659-664. 1955.

Lasley, E. L., and E. A. Kline.
Splitting and cutting errors in swine carcass evaluation. J. Animal Sci. 16:485-489. 1957.

Lu, K. H., L. M. Winters, W. J. Aunan and W. E. Renpel.
Estimating the percentage of lean and fat in swine carcasses. Univ. Minn. Agr. Exp. Sta. Techn. Bul. 224, 1958.

Lush, J. L.
Genetic aspects of the Danish system of progeny testing swine. Iowa Agr. Exp. Sta. Res. Bul. 204, 1936.

McMeekan, C. P.
The nature and variability of the carcass characters of Danish and English bacon pigs. Jour. Agr. Sci. 29:131-141. 1939.

McMeekan, C. P.
The use of sample joints and of carcass measurements as indices of the composition of the bacon pig. Jour. Agr. Sci. 31:1-17. 1941.

North Central Livestock Marketing Research Committee.
Objective carcass grade standards for slaughter hogs. Minn. Agr. Exp. Sta. Bul. 414, 1952.

Pearson, A. M., L. J. Bratzler and W. T. Magee.
Some simple indices for predicting carcass traits of swine. I. Cutout and loin lean area. J. Animal Sci. 17:20-25. 1958a.

Pearson, A. M., L. J. Bratzler and W. T. Magee.
Some simple cut indices for predicting carcass traits of swine. II. Supplementary measures of leanness. J. Animal Sci. 17:27-33. 1958b.

Pearson, A. M., W. T. Magee, L. J. Bratzler and J. A. Hoefer.
Carcass characteristics and cutouts of some different breeds of swine. J. Animal Sci. 18:1482. 1959 (abstract)

Pearson, A. M., L. J. Bratzler, J. A. Hoefer, J. F. Price, W. T. Magee and R. J. Deans.
The fat-lean ratio in the rough loin as a tool in evaluation of pork carcasses. J. Animal Sci. 15:896-901. 1956a.

Pearson, A. M., L. J. Bratzler, R. J. Deans, J. F. Price, J. A. Hoefer and R. W. Luecke.
The use of specific gravity of certain untrimmed pork cuts as a measure of carcass value. J. Animal Sci. 15:86-91. 1956b.

Pork Carcass Evaluation Committee.
Slaughtering, chilling and cutting procedures for pork carcass evaluation. Reciprocal Meat Conference Proc. 5:119-121. 1951.

Price, J. F., A. M. Pearson and E. J. Benne.
Specific gravity and chemical composition of the untrimmed ham as related to leanness of pork carcasses. J. Animal Sci. 16:85-91. 1957.

Self, H. L., R. W. Bray and R. J. Reierson.
Lean cut yield and an evaluation of hams and loins of USDA pork carcass grades. J. Animal Sci. 16:642-653. 1957.

Shaw, A. M.
Variations in the skeletal structure of pigs. Sci. Agr. 10:23-27, 690-695. 1930.

Sinclair, R. D., and J. A. Murray.
Some observations on carcass quality in the bacon hog. Sci. Agr. 16:169-174. 1935.

Skinner, R. L., J. Kastelic, E. A. Kline and Hameyer.
Relationships between physical measurements and the fat and water content of hog carcasses. J. Animal Sci. 13:971. 1954. (abstract)

Snedicor, G. W.
Statistical methods. 5th Edition. The Iowa State College Press. Ames, Iowa. 1956.

Stothart, J. G.
A study of factors influencing swine carcass measurements. Sci. Agr. 19:162-172. 1938.

Stull, J. M.
Photographic methods of measuring longissimus dorsi. Reciprocal Meat Conference Proc. 6:85-87. 1953.

Sumption, L. J., C. H. Adams, R. G. DeBower, C. W. Kasson and L. Stone.
Longer hogs have more eye muscle. Neb. Animal Husb. Dept. Swine Progress Rpt. 371:12-13. 1959.

Wallace, H. D., G. E. McCabe, A. Z. Palmer, M. Kroger, J. W. Carpenter and G. E. Combs.
Influence of slaughter weight on economy of production and carcass value of swine. J. Animal Sci. 18:1484. 1959. (abstract)

Whiteman, J. V., and J. A. Whatley.
An evaluation of some swine carcass measurements. J. Animal Sci. 12:591-596. 1953.

Whiteman, J. V., J. A. Whatley and J. C. Hillier.
A further investigation of specific gravity as a measure of pork carcass value. J. Animal Sci. 12:859-869. 1953.

Wiley, J. R., D. Paarlberg and R. C. Jones.
Objective carcass factors related to slaughter hog value. Ind. Agr. Exp. Sta. Bul. 567:3-34. 1951.

Zobrisky, S. E.
Significant relationships in pork carcass evaluation. J. Animal Sci. 18:583-588; 420-426. 1959.

Zobrisky, S. E., J. F. Lasley, D. E. Brady and L. A. Weaver.
Pork carcass evaluation. Univ. Missouri Agr. Exp. Sta. Res. Bul. 554. 1954.

APPENDIX

APPENDIX A

Table 7. Correlation coefficients between all characteristics studied.

	LW	DW	NW	Dr%	Lh	Lt	NR	BFT	L.lr	L.ll	L.10
LW		.69	.95	-.15	.01	-.11	-.25	.15	.29	.31	.36
DW			.73	.56	-.25	-.31	-.22	.09	.29	.34	.37
NW				-.15	-.04	-.14	-.22	.16	.27	.33	.34
Dr%					-.29	-.26	-.03	-.04	.09	.10	.12
Lh						.96	.43	-.25	.05	.00	-.05
Lt							.52	-.21	-.06	-.12	-.16
NR								.04	-.17	-.15	-.24
BFT									-.33	-.34	-.33
L.lr										.91	.89
L.ll											.87

	L.10r	L.101	L.1	LcL	Lcc	Lcn	Lls	Lrs	RH	TH	TL
LW	.39	.31	.32	.10	.20	.09	.18	.22	.37	.31	.06
DW	.38	.33	.32	.27	.06	.22	.07	.10	.29	.21	.25
NW	.38	.28	.31	.09	.14	.04	.11	.19	.34	.29	.04
Dr%	.09	.14	.09	.24	.11	.23	-.09	-.11	-.00	-.06	-.11
Lh	.02	-.13	.03	.11	.24	.14	.13	.24	-.24	-.06	.38
Lt	-.09	-.24	-.09	.02	.13	.06	.06	.13	-.40	-.21	.33
NR	-.22	-.26	-.16	-.05	-.04	-.05	-.02	-.07	-.32	-.22	.16
BFT	-.32	-.32	-.34	-.59	-.53	-.60	-.51	-.62	-.18	-.42	-.51
L.lr	.88	.86	.98	.67	.66	.63	.61	.67	.55	.72	.55
L.ll	.86	.85	.97	.70	.68	.63	.64	.68	.59	.76	.51
L.10	.98	.98	.90	.63	.61	.58	.55	.64	.56	.71	.48
L.10r		.92	.89	.62	.61	.57	.54	.64	.53	.69	.50
L.101			.87	.62	.59	.58	.53	.62	.57	.70	.44
L.1				.70	.68	.64	.64	.69	.58	.76	.54
LcL					.93	.96	.88	.87	.49	.75	.71
Lcc						.90	.95	.94	.52	.79	.76
Lcn							.85	.85	.41	.68	.71
Lls								.80	.54	.77	.68
Lrs									.50	.78	.76
RH										.87	.91
TH											.43

	FT	LF	BFT1	BFTr	l.lr	l.ll	l.1	l.101	l.10r	l.10
LW	-.14	.01	.16	.14	.25	.34	.27	.33	.34	.35
DW	.00	-.13	.11	.07	.25	.32	.27	.37	.37	.37
NW	-.10	-.01	.17	.15	.24	.34	.26	.30	.33	.33
Dr%	.14	-.16	-.02	-.06	.09	.07	.08	.17	.14	.14
Lh	-.33	.08	-.24	-.25	.08	.07	.08	-.14	.04	-.02
Lt	-.29	.11	-.21	-.21	-.03	.05	-.03	-.21	-.06	-.12
NR	.03	.20	-.05	-.04	-.13	-.13	-.17	-.25	-.20	-.23
BFT	.69	.15	.99	.98	-.35	-.34	-.37	-.34	-.37	-.37
L.lr	-.53	-.14	-.31	-.33	.97	.91	.94	.87	.90	.90
L.ll	-.55	-.15	-.32	-.33	.90	.97	.94	.85	.86	.87
L.10	-.50	-.12	-.30	-.33	.88	.87	.89	.94	.95	.96
L.10r	-.51	-.11	-.30	-.32	.88	.85	.88	.89	.96	.94
L.101	-.45	-.14	-.29	-.32	.85	.84	.86	.96	.90	.93
L.1	-.56	-.15	-.32	-.34	.96	.96	.96	.88	.90	.90
LcL	-.80	-.27	-.59	-.57	.66	.69	.71	.66	.71	.70
Lcc	-.88	-.22	-.58	-.55	.64	.68	.70	.62	.67	.67
Lcn	-.79	-.27	-.60	-.58	.62	.62	.66	.62	.65	.65
Lls	-.82	-.22	-.51	-.49	.58	.61	.63	.56	.59	.59
Lrs	-.84	-.18	-.62	-.59	.68	.70	.72	.64	.71	.71
RH	-.44	-.19	-.18	-.19	.52	.57	.58	.57	.53	.55
TH	-.70	-.18	-.41	-.40	.68	.75	.75	.70	.71	.71
TL	-.69	.09	-.50	-.49	.58	.55	.55	.47	.57	.54
FT		.19	.70	.65	-.51	-.56	-.58	-.49	-.58	-.56
LF			.14	.14	-.10	-.14	-.14	-.16	-.13	-.18
BFT1				.94	-.33	-.32	-.35	-.31	-.36	-.35
BFTr					-.35	-.34	-.36	-.35	-.36	-.36
l.lr						.91	.95	.86	.89	.89
l.ll							.96	.85	.86	.86
l.1								.88	.90	.90
l.101									.93	.97
l.10r										.98
l.10										

.25 = .05 level of significance
.32 = .01 level of significance

Codes for carcass factors:

LW——Live weight
DW——Cold dressed weight
NW——Net body weight
Dr%——Dressing percentage
Lh——Length of carcass (hanging)
Lt——Length of carcass (on the table)

NR——Number of ribs
BFT——Average backfat thickness
L.lr——Loin eye area (last rib, right) 1st observer
L.ll—— " " " (last rib, left) " "
L.10—— " " " (10th rib, average)" "
L.10r—— " " " (10th rib, right) " "
L.101—— " " " (10th rib, left) " "
L.1—— " " " (last rib, average)" "

LF——% leaf fat
BFT1——Average backfat thickness (left side)
BFTr—— " " " (right side)
l.lr——Loin eye area (last rib, right) 2nd observer
l.ll—— " " " (last rib, left) " "
l.1—— " " " (last rib, average)" "
l.101—— " " " (10th rib, left) " "
l.10r—— " " " (10th rib, right) " "
l.10—— " " " (10th rib, average)" "

APPENDIX B

SLAUGHTER DATA

Kansas Swine Testing Station

Manhattan, Kansas

TIME__________ DATE__________

Test No.__________ Lab. No.______

Owner____

Address____

Breed______________________________ Age______________________________

Weight (testing lab.)______________ Weight-slaughter______________________

Scalded Wt.________________________ Hot dressed wt.________________________

Leaf fat—Left______ Right__________ Cold dressed wt.______________________

Yield______________________________

Blood__________ Head______________ Tongue__________ Cheek meat__________

Stomach full_______________________ Small intestines full__________________

Stomach empty______________________ Small intestines empty_________________

Content____________________________ Content____________________________

Penis & Bladder____________________ Large intestines full__________________

Spleen__________ Kidney____________ Large intestines empty_________________

Heart______________________________ Content____________________________

Liver__________ Lungs_____________ Ruffel fat__________________________

Net body wt.______________________

Length of carcass: Hanging-Left__________ Right__________ Av.________________

Table---- " __________ " __________ Av.________________

No. of ribs:--------------- " __________ " __________ Av.________________

Backfat thickness: First rib " __________ " __________ Av.________________

Last rib- " __________ " __________ Av.________________

Last lumbar __________ " __________ Av.________________

Fifth rib __________ " __________ Av.________________

Total Left ______________ Total Right ________________

Average carcass______________________________________

No. Lumbar Vertebrae______________________ Lumbar lean________________

U.S.D.A. - Objective grade____________ U.S.D.A. - Final grade______________

Rhinitis____

APPENDIX C

CUTTING RECORD

KANSAS SWINE TESTING STATION

MANHATTAN, KANSAS

DATE:

Breed: Test No.: Lab. No.:

	TOTAL		Left Side		Right Side	
	LBS.	%	LBS.	%	LBS.	%
Hot dr. wt.						
Cold dr. wt.						
Leaf fat						
Regular Ham						
Tr. Ham						
loin						
B. butt						
Picnic						
Total lean cuts						
Tr. bacon						
Bacon square						
Spare ribs						
Neck bones						
Lean trim						
Feet						

	LBS.	%	LBS.	%	LBS.	%
Tail						
Clear Plate						
Fat Back						
Fat Trim						
Waste						
Total						

Area eye 10th rib R_____________ L_________________ Av._______________

Area eye between 1st and 2nd lumbar R________ L________ Av.___________

APPENDIX D

Table 8. Weight and measurement guides to grades for barrow and gilt carcasses.

Carcass wt. and length	Average backfat thickness (inches) by grade				
	U.S. No. 1	U.S. No. 2	U.S. No. 3	Medium	Cull
Under 120 lbs. or under 27 in.	1.2 to 1.5....	1.5 to 1.8...	1.8 or more..	0.9 to 1.2...	Less than 0.9......
120 to 164 lbs. or 27 to 29.9 in.	1.3 to 1.6...	1.6 to 1.9...	1.9 or more...	1.0 to 1.3...	Less than 1.0......
165 to 209 lbs. or 30 to 32.9 in.	1.4 to 1.7...	1.7 to 2.0...	2.0 or more...	1.1 to 1.4...	Less than 1.1......
210 or more lbs. or 33 or more in.	1.5 to 1.8...	1.8 to 2.1...	2.1 or more..	1.2 to 1.5...	Less than 1.2......

THE RELATIONSHIP BETWEEN VARIOUS PHYSICAL FACTORS OF SWINE CARCASS CHARACTERISTICS

by

GERALD R. HEGARTY

B. S., Kansas State University, 1954

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Husbandry

KANSAS STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE

1960

The increased consumer demand for leaner pork and a decreased acceptance of lard as a shortening has emphasized the need for reliable measures of the fat and lean content of pork carcasses.

The study was undertaken to determine the relative value of certain physical factors of swine carcass characteristics for predicting lean and fat cutouts. Some relationships between these factors have also been investigated.

The data in this study were obtained from 66 purebred barrows from the Kansas Swine Testing Station. Slaughter weight was approximately 200 pounds. By USDA grade, there were 32 No. 1's, 24 No. 2's, and 10 No. 3's. Most of the common modern breeds found in this country were represented.

Simple correlation coefficients were calculated between all possible combinations of 32 measurements and percentage components of the carcasses. The primary factors involved were carcass length, backfat thickness, loin eye area, number of ribs, percent lean cuts, percent fat trim, and percent leaf fat.

A highly significant correlation found between percent skinned ham and percent lean cuts (.79) suggests that percent skinned ham alone may be used as an indicator of carcass value.

Cross sectional loin eye area measured at the last rib averaged about one-half square inch larger than loin eye area at the 10th rib. Correlations between loin eye area and percent lean cuts were .67 and .60 for measurements made at the last rib and 10th rib respectively. These correlations indicate that there may be a higher degree of relationship between loin eye area measured at the last rib and percent lean cuts than between loin eye area measured at the 10th rib and percent lean cuts.

Correlations concerning length showed that carcass length can be accurately measured only when the carcass is hanging on the rail. Correlations also showed that carcass length had little influence on the yield of lean cuts. Correlations between number of ribs and carcass length were highly significant.

Average backfat thickness was found to be a more accurate predictor of fat yield than lean yield in the pork carcass. These data indicate that as backfat thickness increased, not only does the yield of total lean cuts decrease, but the relative proportion of the more valuable cuts (ham and loin) to the less desirable lean cuts of the shoulder decreases.

A poor relationship was noted between leaf fat and the other factors studied.

Highly significant correlations between characteristics of the complete carcass and the same characteristics of a single side of the carcass indicate that one side of the carcass, either the right or left, may be used with confidence to determine carcass value.

The repeatability of tracings of the cross-sectional loin eye area made by two individuals was studied. Correlations between tracings of the same area made by two individuals ranged from .96 to .97. These highly significant correlations emphasize the fact that two or more persons can be utilized in any situation where tracings of carcass tissue areas are being made without introducing a source of error.