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Porcine Body Composition as Influenced by Live Weight

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PORCINE BODY COMPOSITION AS INFLUENCED BY LIVE WEIGHT

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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INTRODUCTION

One of the controversial issues confronting the swine industry is the correct market weight for hogs. When the market prices look favorable for the future the producer tends to put additional weight on his hogs to obtain a greater total return in terms of dollars and cents. The marketing weight is often dependent upon the availability and cost of feed. The area extension worker and nutritionist usually encourage the farmer to market his product at weights which maximize feed efficiency and meat production. Lighter hogs tend to produce faster gain with less feed and produce a leaner, trimmer carcass with less waste. In addition, the carcass may yield a higher percent of lean meat and the lighter weight pigs yield a lighter weight carcass. The lean wholesale cuts from the light carcasses often sell for a premium because most consumers prefer lean pork. Despite the advantages for lighter market weights the packer is still reluctant to purchase light weight hogs because his slaughtering and processing costs are prorated on a per head basis and carcasses are sold by the pound.

The packer is often working on a narrow profit margin on a per carcass basis. Therefore, the profit or loss received by the packer may depend upon the content and value of the offal. At times the profit per carcass in a packing operation may depend on the ability of the packer to utilize and/or merchandise the offal profitably. Most packers do not have reliable data which relate carcass weight to the value of the internal organs and their contents.

This study was designed to evaluate:

(1) The influence of live animal weight on the weights of the offal and contents.

(2) The relationships that may exist between offal weight and carcass composition.

(3) The influence of live weight on carcass composition, particularly edible portion.

REVIEW OF LITERATURE

The evaluation of a meat animal or its carcass is generally based upon the quantity and quality of the lean meat. The quantity factor is very important in live hog evaluation. There are several measures or estimates used to evaluate quantity of lean in an animal or carcass. Lean quantity may be estimated in a carcass by expressing the ham and loin, the four lean cuts or the five primal cuts as a percent of live or carcass weight. The estimated lean quantity of the live animal is related to the market value of that animal. Live weight, sex and breed are some of the factors which may influence quantity. The following discussion will review these factors and their relation to quantity.

Quantity of Lean

Live Animal Evaluation. Live weight is probably the oldest and most often used method of determining the time of hog slaughter. Slaughter weight is important because the pigs should be large enough to yield sufficient amounts of lean of acceptable quality and not so large as to produce excessive amounts of fat.

According to Haugse *et al.* (1957) the weight at which a hog is sent to slaughter is an important factor influencing the return over feed and production costs. Haugse and co-workers collected data from the union stockyards at West Fargo and found the highest price paid throughout the year was for the 190 to 220 lb. animals. Because these weights established the market the greatest return to the producer was obtained from the 200 to 220 lb. weight range.

According to Buck (1963) 3.9 lb. of food was required for 1 lb. of gain between 150 to 200 lb. and 4.3 lb. of food was required for 1 lb. of gain between 200 to 260 lb. Field et al. (1961) found that feed required per 100 lb. of gain averaged less for 160 lb. hogs than for pigs in a 200 lb. weight group. His work indicated that average daily gain from weaning increased throughout the feeding period but at a decreasing rate after the pigs reached 100 lb. Average daily gain reached a maximum at 200 to 210 lb. Braude et al. (1963) reported that as pigs grow older and heavier the efficiency with which their food is converted into live weight decreases and successive increases in live weight are composed of progressively higher proportions of fatty tissue and lower proportions of muscular tissue. The slaughter weight around 200 lb. was preferable to the heavier hogs of 260 lb. both from the production and economic aspect. Mullins et al. (1960) reported that feed costs per 100 lb. gain were increased for pigs as they grew from 42 to 220 lb. McCampbell and Baird (1961) reported that generally as live weight of the pigs increased average daily gain decreased and feed required per 100 lb. gain increased.

Information from 25 packers compiled by Field et al. (1961) indicated that packers preferred hogs weighing 200 to 225 lb. The packers estimated that processing costs were 20% greater per unit weight for hogs weighing under 175 lb. According to the packer it takes practically the same time and facilities to dress, chill and cut the light weight hog as it does a hog that yielded twice as much pork.

Emerson et al. (1961) demonstrated that the light weight hogs compared favorably to the heavy weight hogs in consumer and taste panel acceptability, marbling, curing and smoking properties. The study involved 80 animals ranging in weight from 100 to 210 lb. Similar results were reported by Zobrisky et al. (1960).

Dressing percent is of prime importance to the packer because he is concerned about getting the highest possible percent of the pig into the carcass weight and the lowest possible percent into the less valuable offal. One of the main criteria used by packer buyers in the evaluation of a live animal is dressing percent.

Zobrisky et al. (1959a) reported that dressing percent was one of the most important single measures of live hog value. Bratzler and Margerum (1953) demonstrated that the use of dressing percent in conjunction with weight, length and backfat thickness was a major factor in determining the yield of preferred cuts (ham, loin, shoulder and side) from a live animal. However, results have been reported which are not in complete agreement with this. Pearson et al. (1956) stated that "dressing percent per se is of little importance in evaluating carcass leanness." Price et al. (1957) indicated the dressing percent was not significantly associated with either specific gravity or loin eye area.

Several researchers have reported work regarding dressing percent in relation to live weight. Mullins et al. (1960) showed that pigs from the 220 lb. weight group had a higher dressing percent than those from the 160 lb. group. Wallace et al. (1959) indicated pigs from the 150 lb. group had a lower dressing percent based on empty digestive tract than pigs from the 240 lb. group. Smith (1957) reported that dressing percent was 64% for pigs at 30 lb. and rose to 77% for pigs of 240 lb. live weight. Emerson et al. (1964) also reported that as slaughter weight was lowered there was a decrease in dressing percent. The results from 300 pigs divided into three weight groups were reported by Buck (1963). His work definitely indicated that dressing percent increased as slaughter weight increased from 150 to 260 lb. Results not in complete agreement with the above were reported in 1961 by McCampbell and Baird. Their report indicated that the dressing percent of pigs ranging in weight from 170 to 230 lb. were similar.

Most researchers will agree that previous work has demonstrated that the fatter hogs will have a higher dressing percent. Relating their observations to the development of meat type hogs, Hankins et al. (1952) suggested that fatness is not necessarily the most important factor affecting dressing percentage. They reported that the correlation between thickness of backfat, known to be a good indicator of total fat content, and dressing percentage was 0.42. At a given degree of fatness, dressing percentage varied as much as 4%. In addition, the report indicated that muscular development was a major factor influencing dressing percentage among these hogs. Winters et al. (1952) reported a 0.66 correlation between backfat thickness and dressing percent. Mullins et al. (1960) stated that pigs with greater backfat thickness have a higher dressing percent. Zobrisky et al. (1959a) indicated that dressing percent was significantly correlated with the yield of carcass trim and leaf fat.

Cole et al. (1953) pointed out a highly significant correlation between the type of hog and dressing percentage. The type of hogs produced influences the dressing percent according to Zobrisky et al. (1959b). They reported that wide, deep bodied hogs tend to have a higher dressing percent than the narrow, shallow bodied hogs. They also indicated that carcass length was not significantly correlated with dressing percent. Charette (1961) reported no significant differences among the dressing percent of boars, barrows and gilts.

Fill is generally accepted as the factor having the greatest influence on dressing percent. Other such factors are shrink, viscera weight and various organ weights. The results of work by Zobrisky et al. (1959a) indicate that the weight of the internal organs, the amount of intestinal fill, muscular development, finish and conformation all have an influence on the carcass yield from the live hog. Their work indicated that dressing percent is influenced primarily by the weight of the digestive tract, fill, thoracic organs and head. Based on the National Barrow Show technique (adjusted live weight) Cole (1954) found that dressing percents are about the same when yield is determined on an "equal fill" or empty body weight basis.

Saffle and Cole (1960) measured the effect of fasting upon shrinkage over a period of 24 to 96 hours. The authors indicated that one-half of the total shrinkage occurs during the first 24 hours.

Highly significant differences among fasting periods were found for each of the following: liver, full viscera, full gastro-intestinal tract, full stomach and empty small and large intestine. Clifton et al. (1954) indicated that the amount of normal shrink (not fasted) and the variation herein could be credited primarily to ambient temperature differences. It is not clearly known whether adipose or muscle tissue is most affected during the fasting period. Zobrisky et al. (1954) indicated that there were no consistent trends between grade, fatness and intestinal fill. The suggested possibility was that muscle tissue rather than adipose tissue was utilized by the thinner hogs during the fasting period. Cole et al. (1953) reported that a standard shrink should not be used in carcass evaluation because of the significant difference in percentage of viscera or gastro-intestinal tract between different types of hogs at any given weight.

The literature does not contain much information concerning the variation in organ weights. Saffle and Cole (1960) indicated that as the time of the fasting period was extended the liver weight decreased. The loss in weight was attributed to the depletion of glycogen. Gnaedinger et al. (1963) reported the results of an experiment involving 24 market weight hogs. Their results indicated average weights of 7.8, 10.2, 10.4 and 3.4 lb. for the pluck, head, empty gastro-intestinal tract and the contents of the gastro-intestinal tract, respectively, for 181 to 220 lb. pigs. The lungs, trachea, esophagus, heart, liver, spleen and kidneys were included in the pluck. The gastro-intestinal tract included the stomach, intestines and attached caul and ruffle fat.

Wallace et al. (1959) reported that barrows gained significantly faster than gilts. Comstock et al. (1944) also demonstrated a sex difference in favor of barrows; the barrows slightly excelled the gilts in rate of gain. This difference was noted toward the end of the growth period and may be explained by onset of puberty in the gilt. Cox (1963) in an extensive study involving 7,642 pigs farrowed in six seasons reported the females weighed 5.4% less than the males at 154 days of age. All pigs in this study were weighed and their fat thickness measured by probing. Bennett and Coles (1946) indicated that barrows reached a live weight of 200 lb. 4.34 days earlier than the gilts. However, Charette (1961) found no significant differences in daily gain among barrows, boars and gilts.

The live probe of backfat has proven to be one of the best measures available for predicting carcass cutout value from the live animal. The average of three probe measurements taken over the shoulder, middle of the back and above the ham attachment, all 1 1/2 in. off the midline, has proven accurate. The following men have reported results indicating the backfat probe is a useful tool: De Pape and Whatley (1956), Hazel and Kline (1952), Hetzer et al. (1956), Pearson et al. (1957), Price et al. (1957), Price et al. (1960), Robison et al. (1960), Zobrisky et al. (1959a), Holland and Hazel (1958). The average of three live backfat probes was also a more accurate indicator of percent lean cuts and percent fat than were the carcass measurements, length, area of loin eye at the tenth and last rib and backfat measurement.

Carcass Evaluation. There are several objective carcass measures used to evaluate or predict the amount of lean contained within a carcass. One of the objective measures receiving attention today is loin eye area. Although most workers recognize loin eye area as a useful tool, there is some controversy about the predictive value of different locations on the loin. The most common location today is between the 10th and 11th ribs. However, some meat scientists have suggested that if the measurement was to be taken after the last rib it would correspond to current research in several foreign countries. In addition, the last rib is easier to locate on the live animal which would prove useful for ultrasonics work.

Kline and Hazel (1955) indicated that the loin eye area at the 10th rib is usually about 0.5 sq. in. smaller than the area at the last rib. They also reported that there appears to be very little variation in area from side to side if the same anatomical locations are used for reference points. Hammond (1933) as reported by Buck et al. (1962) demonstrated that the cross section of the loin at the last rib would be the most suitable place because the junction of the loin and thorax anatomical regions develops last. Stouffer and Burgkart (1965) obtained a higher correlation between loin eye at the last rib and total weight of lean in the carcass than between loin eye area behind the 10th rib and total weight of lean in the carcass. Breidenstein et al. (1963) reported that loin eye area measured between the 10th and 11th ribs appeared to be more related to carcass muscling than did the area between the 12th and 13th ribs. Alsmeyer (1957) at the Tenth Annual

Reciprocal Meat Conference reported that in 1956 Pearson and co-workers indicated the area of lean at the last rib had a slightly higher correlation with cutout than area at the 10th rib. Price et al. (1957) indicated that the lean area of the longissimus dorsi behind the 10th rib was superior to the area at the last rib in the prediction of cutout value. Most researchers today use the area of the loin eye muscle between the 10th and 11th ribs (Doornenbal et al., 1962; Holland and Hazel, 1958; Kline and Goll, 1964 and Topel et al., 1965).

Some researchers question the accuracy of the loin eye tracing. Fredeen and Jarmaluk (1962) reported that the accuracy of a tracing was dependent upon the cut to be traced, the complexity of the musculature and the number of individuals responsible for the tracings and planimeter readings. Several researchers have suggested the use of photography as a means of reducing some of the interpersonnel variance.

Most recent workers measure the area of the longissimus dorsi muscle with a compensating polar planimeter. The use of the planimeter came about because of the large variations in the shape of the loin eye muscle. However, Whiteman and Whatley (1953) reported that their method of approximating the size of the loin eye lean area by using the product of the length and width was found to be about as good as a planimeter measure of a tracing of the muscle cross section. In addition, the length and width measurements were easier to obtain than the tracings and planimeter readings. Aunan and Winters (1949) reported that when the effect of carcass weight was eliminated, the loin eye area obtained as a product of width x length was indicative of the amount of lean present in the carcass. Donald (1940) reported that the breadth (width) of the eye muscle increased as live weight increased. The increase in width was attributed to a reduction of growth during the latter stages of fattening.

Loin eye area has been used alone or in combination with other measures to predict lean carcass cutout values. Batcher et al. (1962) demonstrated that loin eye area is a good indicator of the lean content of the ham, shoulder and loin cuts as well as the total percent lean in the carcass. Zobrisky et al. (1954) reported in comparing several measures of leanness that the cross sectional area of the longissimus dorsi gave the highest correlation with the yield of lean in the carcass. Doornenbal et al. (1962), Holland and Hazel (1958), Kline and Hazel (1955), Kline and Goll (1964), Pearson et al. (1956) and Zobrisky et al. (1959a) reported that loin eye area may predict from 30 to 50% of the variation in carcass lean cutout. Zobrisky and co-workers also indicated that loin eye area has a large influence on the value of the highly demanded wholesale loin. Topel et al. (1965) stated that loin eye area was nearly as accurate in predicting the lean cut yield of five different pork muscles as the longissimus dorsi weight. They indicated that the loin eye tracing was much easier and less costly to obtain than the weight of the longissimus dorsi muscle. Using a limited number of samples from 190 to 230 lb. hogs, Cahill et al. (1953) reported that the area of longissimus dorsi (at the 10th and 11th rib) was correlated with the weight of the primal cuts and with the percentage of live weight of the four primal cuts (ham, loin, shoulder and belly) and of the three primal cuts (ham, loin and shoulder).

Research indicates that the relationship of live weight to loin eye development is not linear. Emerson et al. (1964) used 80 pigs divided into four groups balanced according to breeding and sex. The groups weighed 100 to 120 lb., 130 to 150 lb., 160 to 180 lb. and 190 to 210 lb. at slaughter. They reported that the loin eye area at the 10th rib was 2.8, 3.2, 3.5 and 3.8 sq. in. for the 100 to 120 lb. through the 190 to 210 lb. group, respectively. McCampbell and Baird (1961) worked with four weight groups ranging from 170 to 230 lb. They found the loin eye area to be 4.24 sq. in. and 4.43 sq. in. for the first and last groups, respectively. Varney et al. (1962) studied pigs of two weight groups, 159 and 215 lb. Their results indicated that the heavier hogs had significantly less loin eye area when expressed as sq. in. per cwt. of carcass. Wallace et al. (1959) in an experiment involving pigs with live weights of 150, 180, 210 and 240 lb. reported that the loin eye areas measured at the 10th rib were 3.43, 3.85, 4.07 and 4.47 sq. in., respectively. Mullins et al. (1960) conducted a study involving pigs of 160 and 220 lb. They reported that carcasses from the 160 lb. hogs had a larger loin eye area per unit of carcass weight.

Buck (1963) in a study involving 360 pigs in three weight groups reported that the sex difference in favor of the leaner gilt became more pronounced at the heavier weight range. He indicated this difference was noted particularly in the region of the back (loin). Breidenstein et al. (1963) reported that even though mean carcass weights were identical for both sexes (gilts and barrows), the gilt carcasses contained heavier loins than the barrow carcasses. Emerson et al. (1964), Wallace et al. (1959), Carpenter and King (1964), Charette (1961) and Bennett and Coles (1946) pointed out that gilt carcasses yielded larger loin eye areas when compared to barrow carcasses of the same weight group. Judge (1964) indicated that the mean longissimus dorsi areas at five locations were significantly greater in gilts than barrows of the same weight range.

Backfat thickness is an objective carcass measurement which is relatively easy to obtain. Over the past years there have been several attempts to take this measurement at one or at several locations. Most researchers will agree that the most popular and most successful method today involves measurements in three locations, the first rib, last rib and last lumbar vertebrae.

Buck (1963) reported on a study involving 360 pigs which were divided into three weight groups, 150, 200 and 260 lb. His results indicated that gilts possessed less fat than hogs (males) when expressed as a percent of the side at each weight group. Hammond and Murray (1937), Bennett and Coles (1946), Wallace et al. (1959), Noffsinger et al. (1959), Carpenter and King (1964) and Emerson et al. (1964) all reported that gilt carcasses displayed less backfat than barrows.

Aunan and Winters (1949) showed correlations of -.63, -.58 and 0.66 between average backfat thickness and the lean content of the carcass, percent primal cuts and dressing percent, respectively.

Nelson (1962) conducted a study involving 134 gilts and 154 barrows. He demonstrated that backfat thickness was a better predictor of lean cut weight than either length, loin eye area or loin muscle mass. Gnaedinger et al. (1963) reported a correlation coefficient of 0.69 between percent fat in the carcass and backfat thickness. Zobrisky et al. (1954) indicated that there was a high correlation between backfat thickness and total yield of fat in the carcass. Results reported by Batcher et al. (1962) revealed that as backfat thickness increased the percentage separable fat in the trimmed cuts increased. Wiley et al. (1951) reported that as backfat thickness increased so did the weight and yield of fat cuts. They also indicated an inverse relationship between backfat and yield of lean cuts. Stouffer and Burgkart (1965) reported a simple correlation of 0.76 between total fat in the carcass and backfat thickness. Warner et al. (1934) demonstrated that backfat thickness was related to carcass cutout. Kline (1951) showed a high positive correlation between average backfat thickness and the amount of fat in the pork carcass.

Henry et al. (1963) reported a correlation coefficient of -.62 for percent lean cuts on a carcass basis and average carcass backfat. The highly significant correlations Henry and co-workers found between average backfat thickness and percent fat in the shoulder, loin, belly and ham verify that average backfat thickness may be used to predict the fat yield of swine carcasses. Zobrisky et al. (1959a) indicated that a reasonably accurate estimate of the yield of fat can be determined from carcass backfat measurements. They also indicated that the yield of the five primal cuts was negatively correlated with backfat thickness measurements. However, Zobrisky and associates reported that yield of fat can be more accurately estimated in the carcass than the yield of four lean cuts using backfat measurements.

Brown et al. (1951), Whiteman et al. (1953), Carpenter and King (1964), Pearson et al. (1956) and Price et al. (1957) did not obtain high correlations between carcass backfat measurements and carcass cutout.

Pearson et al. (1959) reported that there was less association between backfat thickness and loin eye area for carcasses of 160 to 179 lb. than for the 120 to 159 lb. carcasses. Mullins et al. (1960) reported that backfat thickness averaged 0.4 in. less for pigs of 160 lb. compared to those at 220 lb. McCampbell and Baird (1961) reported that average backfat increased as live weight increased from 170 to 230 lb.

Bruner and Van Stavern (1961) in a study involving over 2,000 pigs reported no statistical difference between age groups for backfat thickness. Age groups varied from 126 to 185 days at 200 lb.

Carcass length as measured from the first rib to the aitch bone is another objective measure used to evaluate the pork carcass. The importance of the carcass length measurement has been discussed by pork producers and meat scientists in the last two years. Some researchers indicate that length is of no value in carcass evaluation. However, pork producers contend that length must be considered because of its relationship to various production traits. Feinstein (1961) reported that Kliesch in Germany found no physiological relationship between length and the fat producing ability of the hog.

Fredeen and Lambroughton (1956), Charette (1961) and Emerson et al. (1964) indicated that gilts possessed greater carcass length than barrows. Buck et al. (1962) reported that gilts were 7.5 mm. longer than barrows at 200 lb. live weight.

McCampbell and Baird (1961) demonstrated an increase in carcass length of 1.8 in. as live weight increased from 170 to 230 lb. Mullins et al. (1960) indicated that pigs of 220 lb. were 2.5 in. longer than pigs that weighed 160 lb. live. Bruner and Van Stavern (1961) in a study involving 2,433 pigs reported that there was no statistical difference between age groups for carcass length. The age groups varied from 126 to 185 days of age at 200 lb.

Robison et al. (1952) reported that as length increased and as backfat thickness decreased the percentage of lean cuts increased and the percentage of fat trimmings decreased. Nelson (1962) demonstrated that body length was associated with an increase in longissimus dorsi mass. However, Nelson reported that including the length measurements in any of the correlations did not appreciably improve the association with measures of lean. Bay (1960) cited work of Nebraska scientists which revealed a positive correlation of 0.45 between length of carcass and percentage lean cuts. Pearson et al. (1958) indicated that as length increased the percentage of loin also increased. Hutchinson (1951) reported that as the ratio of length to carcass weight increased so did the value of the carcass. Zobrisky et al. (1959a) reported that partial correlation analysis indicated that carcass length was correlated with carcass width and backfat thickness. Zobrisky and co-workers also indicated that carcass length was not significantly correlated with dressing percent.

Price et al. (1957) reported that carcass length showed no significant relationship with cutout data, chemical composition or exterior fat thickness. Henry et al. (1963) reported that carcass length had very little influence on leanness of pork carcasses. They demonstrated low correlations between carcass length and other carcass measurements. Henry and co-workers reported a correlation coefficient of 0.28 between carcass length and percent lean on a carcass basis. Pearson et al. (1956) indicated that carcass length measurements have a low relationship with both muscling of the loin and lean cutout figures. Carpenter and King (1964) found a negative correlation (-.56) between average daily gain and carcass length. Bowman et al. (1962) stated that carcass length was of little value as an index of percent separable lean.

Another objective measure used to evaluate the pork carcass is the relative amount of various cuts and their components such as lean, fat and bone. The accurate measurement of muscling has been a major problem in pork carcass evaluation. However, in spite of the shortcomings (slowness, subjective decisions in dividing the tissue into its component parts and losses due to evaporation and absorption) of the dissection-separation technique, it appears to be a valid measure of muscling. Smith et al. (1964) reported on their study involving physical separation of 20 pork carcasses weighing approximately 140 lb. They found the average component tissue values to be 9.0% bone, 4.5% skin, 43.3% fat and 43.0% lean for total carcass composition. They reported that based on correlation coefficients the most reliable indicator cuts were as follows: percent bone in ham with percent carcass bone, 0.95; percent skin in belly with percent carcass skin, 0.93; percent fat in whole loin with percent carcass fat, 0.93 and percent lean in whole loin with percent carcass lean, 0.89. Associations between percent carcass weight in closely trimmed primal cuts, in combination or individually, were not high enough to be of predictive value in estimating dissectible carcass fat or lean. The percent of carcass as lean primal cuts was correlated with total carcass lean (0.68) and with total carcass fat (-.64). Percent of carcass weight in trimmed ham was correlated with total carcass lean (0.60) and with total carcass fat (-.60). Lu *et al.* (1958) showed the relationship which existed between various cuts and the carcasses. They reported that as carcass length increased there was a tendency for a decrease in ham lean and loin fat. Zobrisky *et al.* (1959b) showed a high correlation (0.73) between the amount of fat trimmed from the skinned ham and the yield of fat from the carcass. Aunan and Winters (1952) obtained cores from five sites within the carcass and these cores were then separated. Their work indicated that the core from the fifth to sixth rib section of the belly had the highest correlation (0.79 ± 0.04) with the actual lean content of the carcass. Alsmeyer (1957) at the Tenth Annual Reciprocal Meat Conference reported that Cahill, Sutton and Kunkle at Ohio State obtained high correlations between area of _longissimus dorsi_ at the 10th rib and weight and percentage of primal cuts. Alsmeyer also reported that Fredeen, Bowman and Stothart compared several techniques of estimating carcass leanness and reported a high association of loin eye area at the last rib with percent lean of the ham. They found the percent of lean in the proximal face of the ham a superior measure of carcass leanness when compared to the loin eye area measure.

Physical separation is usually employed on one side only. Results from Breidenstein _et al._ (1963) clearly indicated that bilateral symmetry prevailed. Side differences for all physical and chemical measurements were nonsignificant. Bowman _et al._ (1962) indicated that the lean of the carcass was separated with the greatest accuracy and bone with the least. In an analysis of side to side variation they indicated that specific gravity and linear measurements of backfat and length could be taken on one side. However, Gatherum (1957) indicated that both sides of the carcass must be measured for backfat and length to get a representative figure. Lasley and Kline (1957) working with 222 barrows reported the left side averaged heavier, yielded heavier loins, hams, picnics, lean cuts and primal cuts but lighter bellies and boston butts. Failure to divide the carcass into equal halves was partly responsible for the differences. The coefficient of variation was largest for the cuts which required several cutting steps. They also indicated the advantage of separating both sides was diminished as the repeatability in separation was increased. No significant side difference was found for loin eye area. They attributed one-half of the cutting variation for lean cuts to the lack of precision in cutting the loin. Ham weight is more reliably estimated than is any other wholesale cut or combination of cuts. If only one side is evaluated, it is important that it be always the same side. They indicated that when both sides of the carcass were separated and averaged greater precision was achieved. Breidenstein et al. (1964) reported that bilateral asymmetry was not detected and the difference from left to right sides may be wholly attributable to experimental error.

Stouffer and Burgkart (1965) showed simple correlations among the following: total weight of lean in the carcass versus ham weight, 0.82; lean in the ham, 0.93; lean in the loin, 0.82; loin eye area at the last rib, 0.72 and lean in the shoulder, 0.72. They reported a simple correlation of 0.83 between total fat in the carcass and fat in the loin. Stouffer and Burgkart also obtained a multiple correlation coefficient of 0.92 by associating loin eye area at the last rib and weight of the ham with weight of the separable lean in the carcass. Zobrisky et al. (1959a) demonstrated that loin eye area and yield of loin, ham or shoulder were correlated with the yield of four lean cuts. These same variables were significantly correlated with the yield of the five primal cuts but to a lesser degree than with the four lean cuts.

Henry et al. (1963) reported highly significant correlations between percent lean cuts and percent protein of various cuts. The authors indicated that a highly significant correlation existed between percent lean cuts and longissimus dorsi area. Of all the variables Henry studied, the percent skinned ham was the most highly associated with lean cuts. Carpenter and King (1964) reported that loin eye area, ham width, percent ham, loin or shoulder and carcass value were significantly and positively associated with percent lean cuts with simple correlation coefficients of 0.54, 0.45, 0.74, 0.75, 0.78 and 0.59, respectively. Bowman et al. (1962) indicated the weights of lean and fat in the ham were highly associated with leanness (0.92).

Judge (1964) reporting on comparisons of genetically similar barrows and gilts indicated that gilt data were generally less variable than that of barrows. Correlation coefficients between longissimus dorsi area and the weight of loin edible portion were much lower for gilts than for barrows. Bruner and Van Stavern (1961) reported that loin eye size and percent lean cuts were significantly correlated with the age group for gilts. They indicated that as gilts mature the loin eye tends to be larger and the percentage of lean cuts greater.

Pearson et al. (1959) reported results that indicated the depth of lumbar lean can be used as an indicator of loin eye area. The ratio of depth of lumbar lean plus fat to depth of lumbar lean was equally as reliable an indicator of loin eye area and had the added advantage of being a good indicator of carcass cutouts. Their findings suggest that either the depth of the multifidus dorsi or the over-all depth of the above and the gluteus medius may be used to indicate size of loin eye. They reported that this technique was more effective in evaluating light weight hogs than heavy hogs. They hastened to add that this index had little advantage over the use of backfat thickness. Whiteman and Whatley (1953) utilized the area of the ham in similar work. They used two methods in obtaining area; namely, as a product of length times width and measurement of area with a planimeter. Their findings indicated that the planimeter measure was more accurate; however, it was less closely associated with carcass leanness than either specific gravity or backfat thickness.

Another method of determining relative carcass value is the chemical analysis of the carcass for moisture, protein, fat and ash. Warner et al. (1934) when evaluating cutting yields as an index of fatness indicated that the chemically determined fat in the edible portion was highly correlated (0.91±0.01) with the percent yield of fat cuts. Pearson et al. (1957) reporting on results from Kline and Hazel (1955) along with Price et al. (1957) indicated that data on cutout and chemical analysis demonstrated that the "loin eye" is not closely correlated with total muscling of the entire carcass.

Live weight has a marked influence upon body composition. Varney et al. (1962) reported on the results of a trial involving two groups of 30 Hampshire barrows averaging 159 and 215 lb. The 215 lb. hogs had higher carcass yields than the 159 lb. hogs. However, the heavier hogs had 0.4 in. more backfat and significantly less loin eye area when expressed as sq. in. per cwt. carcass. In percent of total weight of individual cuts the heavy hogs were higher in boneless ham but also higher in ham fat and skin. In contrast, the light group was higher in boneless-defatted ham and boneless-defatted ham cushion but higher in ham bone. This indicates a greater ratio of lean to fat in the light hogs with the advantage being diminished somewhat by the higher bone percent. The heavier hogs yielded a higher percent of skinless smoked bacon. The light hogs were higher in percent of lean and primal cuts on a live weight and carcass basis. The heavier hogs were higher in percent of lard stock available. In an earlier study Warner et al. (1934) using heavy hogs (250 lb. or more) and lighter hogs (less than 130 lb.) reported the heavy hogs possessed the largest percent of fat and the smallest percent yield of two lean cuts (ham and loin). A correlation between weight of trimmed ham and loin expressed as a percentage of entire cold carcass and the fat content of the edible portion of the carcass was -.77. The results obtained from these correlations indicate a high relationship between changes in actual fatness of a hog and changes in the percent of its various parts or cuts.

Mullins et al. (1960) reported the results of a trial involving 100 pigs divided by sex, weight and litter into two lots. Results indicated that carcasses from 220 lb. hogs had greater backfat thickness, higher dressing percent and a higher percent fat trim. Carcasses from the 160 lb. hogs had a higher percent of four lean cuts, primal cuts and a larger loin eye area per unit of carcass weight. Wallace et al. (1959) worked with 128 pigs in weight groups of 150, 180, 210 and 240 lb. They reported an average backfat thickness of 1.12, 1.26, 1.47 and 1.51 in. and percent lean cuts of 53.77, 53.35, 51.06 and 49.33 for the weight groups of 150, 180, 210 and 240 lb., respectively. Field et al. (1961)

conducted a study comparing light (160 lb.) and normal market weight hogs (200 lb.). They reported the lighter hogs produced significantly more lean cuts, ham, loin, picnic and boston butt, and more primal cuts, ham, loin, picnic, boston butt and belly. They demonstrated that the extra value of these well muscled light hogs offset the added packer cost of processing them.

Buck (1963) made a comparison of 360 pigs slaughtered at three different weights, 150, 200 and 260 lb. Results of the growth between 150 to 200 lb. indicated that on the average an increase of 15.5 lb. of lean was accompanied by 16.0 lb. of fat and skin and 2.5 lb. bone. Growth between 200 to 260 lb. indicated that hogs (males) put on 16.0 lb. of lean with 24.0 lb. of fat and skin and 2.5 lb. of bone while gilts put on 19.0 lb. of lean, 21.2 lb. of fat and skin and 2.5 lb. of bone. For both sexes but especially for males the increase in fat and skin as a percentage of the lean increase was greater during this 200 to 260 lb. growth interval than the corresponding values in the 150 to 200 lb. interval. Buck reported that weights of the different cuts as a percent of the side weight does not appear to change much between slaughter weights. The carcass becomes less lean as slaughter weight increases and this difference in leanness is more pronounced between 200 to 260 lb. than between 150 to 200 lb. Buck indicated that for all cuts and for both sexes the percent of lean meat added in the range of 200 to 260 lb. live weight is less than that for the range of 150 to 200 lb.

The results of an experiment involving 80 pigs divided into groups 1 to 4, 100 to 120 lb., 130 to 150 lb., 160 to 180 lb. and 190 to 210 lb., were discussed by Emerson et al. (1964). Significant ($P < .01$) differences between each weight group were observed in backfat thickness, carcass length and area of loin eye. Significant differences were also noted in dressing percent and percent of lean cuts from carcass weight groups 1 to 3. As slaughter weight decreased, there was a decrease in carcass length, dressing percent and loin eye area and an increase in the percent of primal and lean cuts. Percent lean cuts on a carcass basis decreased from 57.5 to 53.2 and percent primal cuts on a carcass basis decreased from 69.0 to 65.9 for weight groups 1 to 4, respectively. Physical separation of the rough ham indicated that percent bone decreased from 10.1 to 7.9, percent lean decreased from 63.5 to 52.2 and percent fat increased from 22.0 to 29.5 for weight groups 1 to 4, respectively. McCampbell and Baird (1961) reported on carcass evaluation of swine slaughtered at four weights: lot 1 = 170, lot 2 = 190, lot 3 = 210 and lot 4 = 230 lb. The percent lean cuts and primal cuts decreased as market weight increased (based on weight off test), lot 1 = 37.5, 45.6, lot 2 = 36.3, 45.2, lot 3 = 36.2, 44.7 and lot 4 = 35.1, 44.7. Analysis of variance results of the ratios of carcass length, average backfat and loin eye area per cwt. carcass weight indicated that lot 1 was significantly higher than lot 4 for carcass length and loin eye area ratios. Lu et al. (1958) indicated that as carcass weight increased the percentage of shoulder became greater while the percent of loin became less. There was no apparent effect upon the percent of ham and belly.

Bennett and Coles (1946) reported distinct sex differences with the gilts being heavier in the shoulder and ham but lighter in percent middle than the barrows. In accordance with these results Hammond and Murray (1937) reported that when barrows and gilts were of the same length the barrows had a thicker belly. Hetzer et al. (1950) reported that gilts averaged 0.72% more lean in the ham than did the barrows. Heidenreick et al. (1961) indicated that gilts had less fat and were smaller in heart girth and flank circumference than the barrows.

Cuthbertson and Pomeroy (1962) demonstrated that bone completes a greater proportion of its growth earlier in life, while the rate of fat deposition increased with age. Breidenstein et al. (1963) reported the femur weight was significantly heavier in barrows than in gilts, although the barrows had lighter ham muscles. This would suggest that muscle and bone development may not be directly related.

METHODS OF PROCEDURE

The project consisted of 64 pigs, 32 Yorkshires and 32 Hampshires. One-half of each breed was females, the other half barrows. The pigs were allotted shortly after weaning into lots consisting of 16 pigs each (weight groups). Each weight group was balanced according to breed and sex. All the pigs were fed a similar balanced ration and managed in the same manner. The desired final weights were 150, 180, 210 and 240 lb. When a pig reached the predetermined weight plus 10 lb., it was removed from the feeding trial. The desired weight for each weight group was based on a 24 hour shrink rather than an off-feed basis.

After reaching the desired off-feed weight, the pigs were transported to the holding facilities at the South Dakota State University meat laboratory. In the holding facilities the pigs were subjected to a 24 hour shrink with access to water but not feed.

Before slaughter each animal was weighed to the nearest pound on the scale in the holding facility. Directly following the weighing, the pig was taken to the slaughter area, stunned, hung up and bled. After bleeding, the excess blood was wiped from the exterior of the carcass and the carcass was weighed to obtain a blood weight by difference. The pig was then scalded in 143° F. water and the hair and toenails were removed. Following the hair removal, the carcass was wiped dry and weighed to obtain a hair and toenail weight by difference. Next, the head was removed at the atlas joint, leaving the jowls on the carcass. The tongue was removed from the head and the head and tongue were weighed to the nearest one-tenth lb.

The carcass was then opened down the ventral midline. The complete viscera was removed and weighed as a single unit. The liver and spleen were then separated from the viscera and weighed individually. Next, the caul fat was removed from the stomach and weighed. The stomach was cut from the small intestine adjacent to the pylorus, weighed, emptied, washed and weighed empty. The weight of the contents of the stomach was obtained by difference. The ruffle fat from both the large and small intestine was removed and a weight was obtained for each portion. The large and small intestine were each weighed full, washed out and an empty weight was recorded. The content of the large and small intestine was figured by difference. The combined weight of the reproductive tract and visceral trimmings was recorded.

The leaf fat and kidneys were removed from the carcass and weighed separately. The sternum was split, and the pluck was removed and weighed. The heart and lungs were cut from the pluck and a separate weight was recorded for each. The carcass was split into two equal halves using a power saw. The last step of the slaughter procedure was to obtain a hot carcass weight before going to the cooler.

The carcasses were chilled for at least 48 hours at a temperature of 36 to 38° F. Backfat and length measurements were taken at 24 and 48 hours on both the right and left sides. Average 48 hour measurements from both sides were used in the analysis. Wholesale cuts were made according to the procedure as outlined in the Proceedings of the Fifth

Annual Reciprocal Meat Conference by Cole (1952) and weighed. Trimming as described in the following detailed procedure for each cut was completed before a trimmed wholesale cut weight was obtained (Fletcher, 1964). Further processing involved the separation of each wholesale cut into edible portion, bone and fat trim components. The edible portion (hereafter referred to as E.P.) is used to denote that portion of the lean which was trimmed to one-fourth in. external fat. In the boning process excessive intermuscular fat deposits were also removed. All weights were recorded to the nearest one-tenth lb. Both right and left sides of each carcass were cut and the weights used in the analysis of variance are an average of the individual cuts from each side.

The individual wholesale cuts were handled in the following manner.

A. Shoulder

1. A six by nine in. sheet of acetate tracing paper was placed at the dorsal edge of the shoulder on the cut surface between the shoulder and loin. The tracings included lean thickness, fat thickness, neck bones and the blade bone. The lean thickness (A-B) and fat thickness (B-C) were measured perpendicular to the ventral junction of the <u>multifidus dorsi</u> (D) and the area of the third to fourth thoracic vertebrae (E) as shown in figure 1.

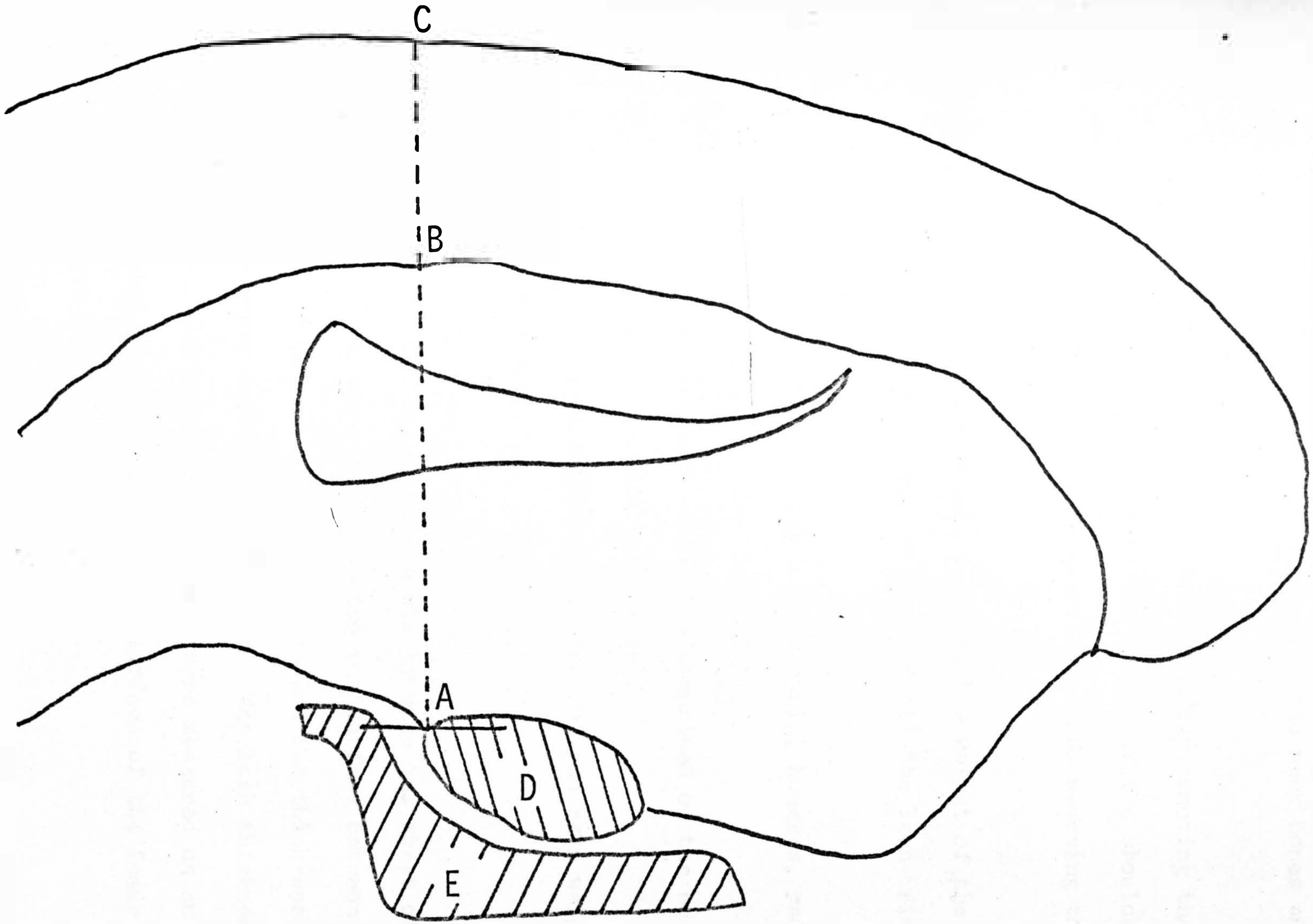

Figure 1. Lean thickness (A-B) and fat thickness (B-C) measures of the shoulder.

2. The green weight of the shoulder included the shoulder proper with the foot intact, and the neck bones and jowl removed.

3. The trimmed weight was obtained after removing the clear plate down two-thirds of the length of the shoulder, trimming the fat to one-fourth in. and removing the foot.

4. The weight of the E.P. included the weight of the boned and tied boston butt, picnic and all the lean trim from the shoulder.

5. The bone weight included the scapula, humerus, radius-ulna but excluded the foot weight.

6. The boneless roast weight was comprised of the boned and tied boston butt and picnic.

7. The fat weight included both the fat and skin weight from the shoulder.

B. Ham

1. The ham tracing made on a six by nine in. sheet of acetate tracing paper, at the cut surface between the ham and loin, included the lean and fat thickness and the cross section of the femur. The lean thickness (A-B) and fat thickness (B-C) were measured on an axis perpendicular to the lateral surface of the femur as shown in figure 2.

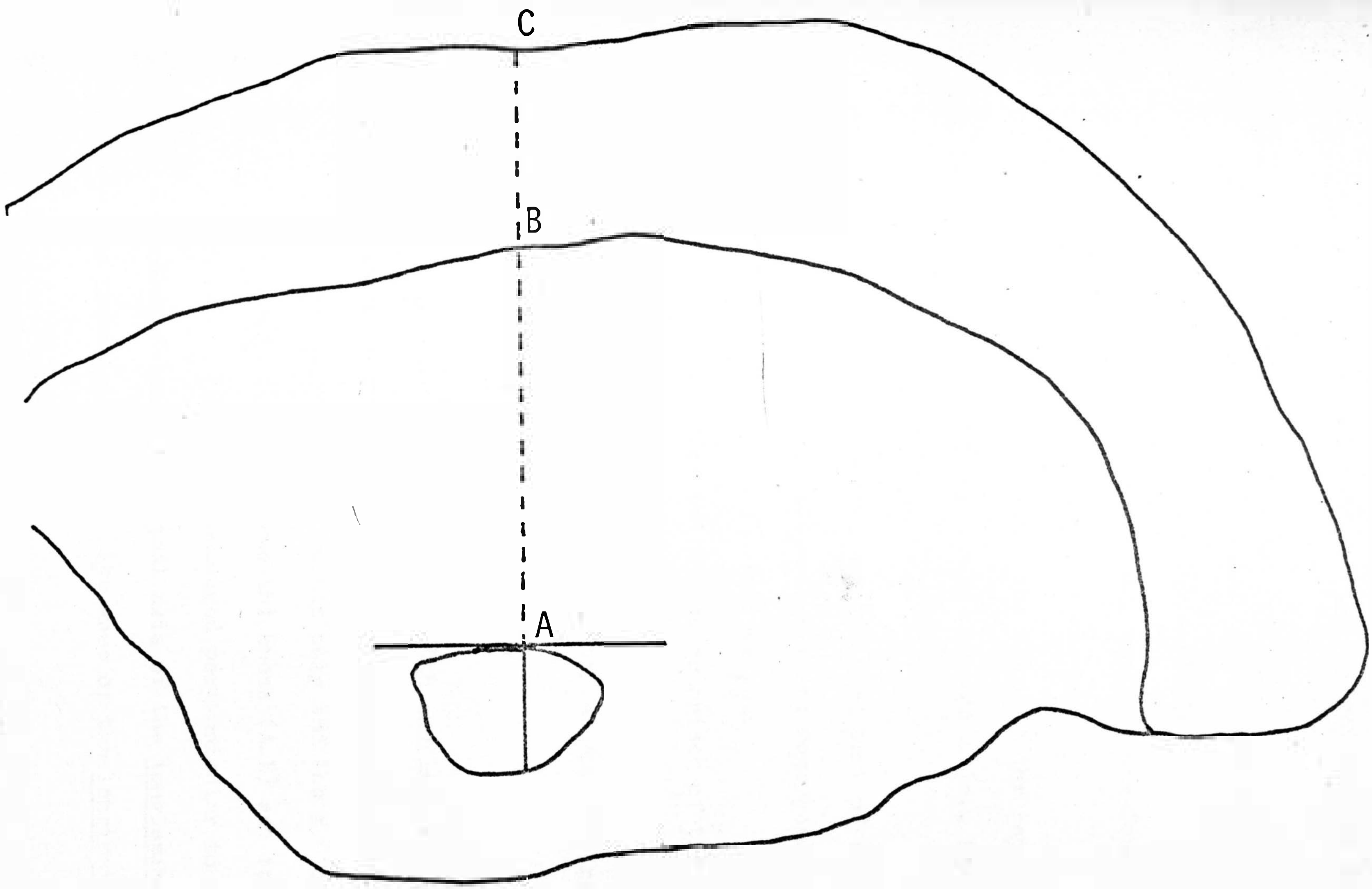

Figure 2. Lean thickness (A-B) and fat thickness (B-C) measures of the ham.

2. The green weight included the entire ham with the foot intact.
3. The trimmed weight included the ham with the foot removed about one in. above the tibia-fibula tarsal joint with the skin and fat trimmed uniformly to one-fourth in. down one-half the length of the ham.
4. The E.P. weight included the ham with the remaining skin removed, the fat trimmed to one-fourth in., the bones removed plus the lean trim.
5. The bone weight of the ham included part of the pelvic girdle, the femur, tibia-fibula and coccygeal vertebrae but did not include the foot weight.
6. The boneless roast weight was comprised of the boned and tied ham.
7. The fat weight included both the fat and skin removed from the ham.

C. Loin

1. The loin was cut between the 10th and 11th rib and a tracing was made on acetate tracing paper which included the longissimus dorsi muscle only and the fat covering of the muscle. The lean thickness (A-B) and fat thickness (B-C) were measured perpendicular to the mid-point of the longitudinal axis of the longissimus dorsi as shown in figure 3. The area of the longissimus dorsi

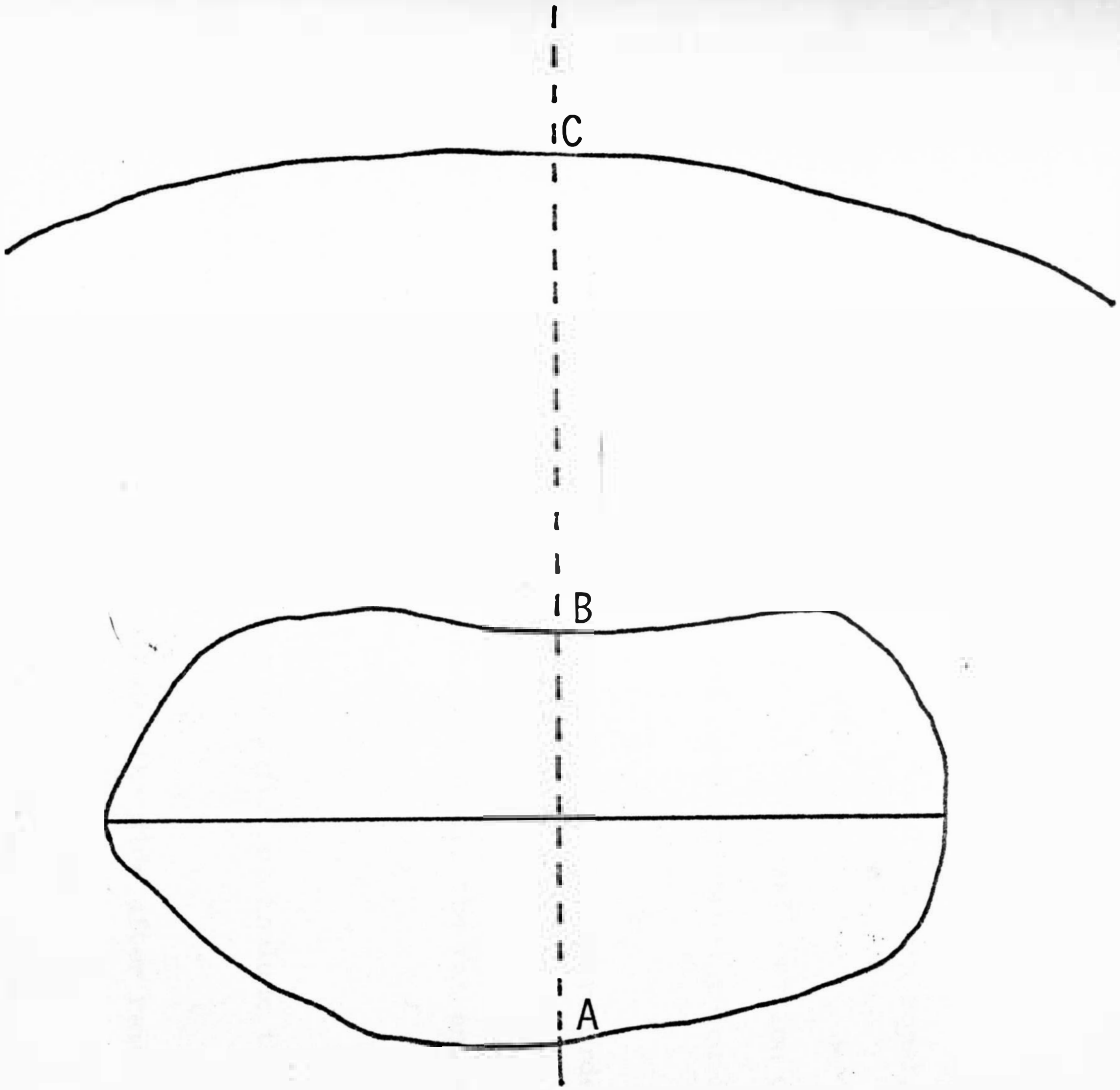

Figure 3. Lean thickness (A-B) and fat thickness (B-C) measures of the loin.

was measured in sq. in. using a compensating polar planimeter.

2. The green weight consisted of the intact loin.
3. The trimmed loin weight included the loin with the fatback removed leaving one-fourth in. of fat uniformly over the loin.
4. The E.P. weight included the boneless loin roast, tenderloin and the lean trim.
5. The bone weight was composed of a small portion of the scapula, and the ribs and vertebra normally found in the loin.
6. The weight of the boneless loin roast was recorded separately.
7. The fat weight was comprised of all the fat and skin removed from the loin.

D. Side

1. The green weight of the side did not include the weight of the spare ribs.
2. The trimmed weight included the side after removal of the teat line and additional squaring.
3. The trimmed belly was separated into fat, skin and the lean trim which approximated a lean fat ratio of 3:1.
4. The total lean trim obtained from the side was combined for the E.P. weight.

5. The fat weight of the side included the fat trimmed from the side plus the skin weight.

E. Bone cuts

1. The spare ribs and neck bones were included in this group.

2. The E.P. weight was the total lean trim from the spare ribs and neck bones.

3. The bone weight included the neck bones, ribs and sternum.

F. Jowl

1. The E.P. weight included all the lean after removal of the excessive fat.

2. The fat weight included fat and skin removed from the jowl.

G. Foot

1. Both feet were weighed intact.

All data were placed upon IBM cards and the analysis of variance obtained using the factorial design with equal subclass numbers. Simple correlations were also calculated using the computer. The data for these relationships will be presented in the section immediately following the discussion of the analysis of variance.

RESULTS AND DISCUSSION

Live weight was the major variable in this experiment. Therefore, the effect of live weight on each weight, measurement or percentage will be discussed first followed by discussion of breed, sex and the interactions. Means for each variable are listed in the appendix by weight group, breed and sex.

Rate of daily gain (table 1) was significantly influenced by weight, breed and sex. The average daily gain for the four weight groups was 1.14 lb. per day with a standard deviation of 0.12 lb. The mean rate of gain for the 150, 180, 210 and 240 lb. groups was 1.09, 1.08, 1.20 and 1.20 lb., respectively. The Hampshires gained 1.17 lb. per day as compared to the Yorkshires which gained 1.12 lb. per day. This difference was significant ($P < .05$). There was a highly significant ($P < .01$) difference between sexes as the barrows gained 1.20 lb. per day compared to the gilts which gained 1.09 lb. per day.

Animal age at slaughter, which varied from 152 to 211 days for the 150 and 240 lb. weight groups, respectively, was significantly ($P < .01$) influenced by weight and sex. The gilts were 190 days and the barrows were 174 days old at slaughter time. There was a difference of six days in age between the Yorkshires and Hampshires; however, this difference was not significant.

Slaughter Weights and Measurements

Head weight (table 1) was significantly influenced by weight ($P < .01$) and the breed x sex interaction ($P < .05$). The group means were

TABLE 1. ANALYSES OF VARIANCE FOR RATE OF DAILY GAIN, ANIMAL AGE AT SLAUGHTER, HEAD WEIGHT, VISCERA WEIGHT, PLUCK WEIGHT, LIVER WEIGHT AND SPLEEN WEIGHT

		Mean squares						
Source	d.f.	Rate of daily gain	Animal age at slaughter	Head wt.	Viscera wt.	Pluck wt.	Liver wt.	Spleen wt.
Weight	3	0.07**	9596.93**	37.29**	90.05**	2.75**	1.11**	0.09**
Breed	1	0.04*	669.51	0.10	0.02	1.96**	1.29**	0.01
Sex	1	0.21**	3921.89**	0.06	1.56	0.00	0.00	0.03*
Weight x breed	3	0.01	247.94	0.38	2.68	0.01	0.01	0.00
Weight x sex	3	0.00	117.48	0.67	0.15	0.30	0.03	0.00
Breed x sex	1	0.00	40.64	2.36*	11.56	0.08	0.15	0.00
Residual	51	0.01	228.37	0.45	4.06	0.17	0.10	0.00
Total	63							

* $P < .05$.
** $P < .01$.

8.5, 10.0, 11.0 and 12.1 lb. for the 150, 180, 210 and 240 lb. groups, respectively.

Total viscera weight (table 1) increased significantly ($P < .01$) from 15.7 to 21.1 lb. as live weight increased from 150 to 240 lb. The total mean for the complete viscera was 18.0 lb. with a standard deviation of 2.8 lb.

The complete pluck weight (table 1) was significantly ($P < .01$) influenced by weight groups and breeds. The means were 3.3, 3.9, 4.1 and 4.3 lb. for the 150, 180, 210 and 240 lb. groups, respectively. When groups were combined, the mean was 3.9 lb. with a standard deviation of 0.56 lb. A highly significant ($P < .01$) difference existed in pluck weight between the Hampshire and Yorkshire breeds. The Hampshires had a pluck weight of 4.1 lb. and the Yorkshires had a 3.7 lb. pluck.

Weight and breed significantly ($P < .01$) influenced liver weight, also (table 1). The mean liver weights were 2.7, 2.8, 3.0 and 3.3 lb. for the 150, 180, 210 and 240 lb. groups, respectively. The Hampshires showed a mean liver weight of 3.1 lb. while the Yorkshire mean weight was 2.8 lb.

The spleen weight (table 1) was significantly influenced by weight ($P < .01$) and sex ($P < .05$). The mean spleen weights were 0.29, 0.36, 0.38 and 0.47 lb. for the 150, 180, 210 and 240 lb. groups, respectively. The gilts had a slightly heavier spleen weight than the barrows.

The analyses of variance for the weight of the caul fat, full stomach, empty stomach, stomach contents, full small intestine, empty small intestine and small intestine contents are given in table 2.

As live weight increased, caul fat weight and full stomach weight increased significantly ($P < .01$). The caul fat mean weight for all pigs was 0.5 lb., whereas the means ranged from 0.36 to 0.61 lb. for the 150 and the 240 lb. groups, respectively. The mean full stomach weights for the 150, 180, 210 and 240 lb. groups were 1.4, 1.7, 1.8 and 2.0 lb., respectively.

Weight of the empty stomach was significantly influenced by weight ($P < .01$) and the interactions weight x sex ($P < .05$) and breed x sex ($P < .05$). The means were 1.11, 1.34, 1.41 and 1.60 lb. for the 150, 180, 210 and 240 lb. groups, respectively. Table 3 is presented to show the means for the weight x sex interaction.

Empty stomach weight was highest for the barrows in the 150 and 210 lb. groups. The females had a slightly higher empty stomach weight in the 180 lb. group and both sexes showed the same empty stomach weight for the 240 lb. group.

The means for the breed x sex interaction are listed in table 4. In the Yorkshire breed the females showed the heaviest empty stomach weight; however, in the Hampshire breed the barrows had the heaviest empty stomach weight.

TABLE 2. ANALYSES OF VARIANCE FOR THE WEIGHT OF CAUL FAT, FULL STOMACH, EMPTY STOMACH, STOMACH CONTENTS, FULL SMALL INTESTINE, EMPTY SMALL INTESTINE AND SMALL INTESTINE CONTENTS

		Mean squares						
Source	d.f.	Caul fat wt.	Full stomach wt.	Empty stomach wt.	Stomach contents wt.	Full small intestine wt.	Empty small intestine wt.	Small intestine contents wt.
Weight	3	0.19**	1.06**	0.63**	0.07	0.54	0.18	0.12
Breed	1	0.11	0.00	0.02	0.00	0.00	0.47	0.54
Sex	1	0.00	0.11	0.01	0.29	0.79	0.47	0.02
Weight x breed	3	0.04	0.09	0.02	0.05	0.75	0.06	0.36
Weight x sex	3	0.08	0.02	0.09*	0.06	0.51	0.26	0.04
Breed x sex	1	0.01	0.00	0.11*	0.05	0.29	0.38	0.07
Residual	51	0.03	0.14	0.03	0.09	0.63	0.32	0.17
Total	63							

* $P < .05$.
** $P < .01$.

TABLE 3. MEANS FOR THE WEIGHT X SEX INTERACTION FOR EMPTY STOMACH WEIGHT

Sex	Weight, lb.			
	150	180	210	240
Females	1.07	1.36	1.36	1.60
Barrows	1.16	1.33	1.46	1.60

TABLE 4. MEANS FOR THE BREED X SEX INTERACTION FOR EMPTY STOMACH WEIGHT

Breed	Sex	
	Females	Barrows
Yorkshire	1.40	1.30
Hampshire	1.36	1.42

The analyses of variance for weight of stomach contents, full small intestine weight, empty small intestine weight and small intestine contents weight indicated that they were not affected by weight, breed or sex. This may have been true because the pigs were all held off feed 24 hours before slaughter. The constant shrink would tend to equalize the weight of the viscera contents particularly in the first part of the intestinal tract.

Table 5 gives the analyses of variance for weight of the full large intestine, empty large intestine, large intestine contents, total ruffle fat, total visceral contents, leaf fat and total mesenteric fat. All of these weights except total visceral contents were significantly influenced by live weight.

TABLE 5. ANALYSES OF VARIANCE FOR WEIGHT OF FULL LARGE INTESTINE, EMPTY LARGE INTESTINE, LARGE INTESTINE CONTENTS, TOTAL RUFFLE FAT, TOTAL VISCERAL CONTENTS, LEAF FAT AND TOTAL MESENTERIC FAT

		Mean squares						
Source	d.f.	Full large intestine wt.	Empty large intestine wt.	Large intestine contents wt.	Total ruffle fat wt.	Total visceral contents wt.	Leaf fat wt.	Total mesenteric fat wt.
Weight	3	14.06**	3.41**	4.30*	2.33**	5.63	20.80**	3.76**
Breed	1	4.36	0.01	5.82*	0.18	3.66	1.76	0.53
Sex	1	2.44	0.12	1.35	0.42	0.11	1.27	0.36
Weight x breed	3	2.18	1.10*	0.57	0.05	0.49	0.04	0.04
Weight x sex	3	0.70	0.01	0.59	0.13	0.78	0.54	0.25
Breed x sex	1	12.69**	1.82*	5.01*	0.05	3.66	0.49	0.09
Residual	51	1.55	0.28	1.20	0.23	1.93	0.51	0.26
Total	63							

* $P < .05$.
** $P < .01$.

Full large intestine weight was significantly influenced by weight ($P < .01$) and the breed x sex interaction ($P < .01$). The mean weight of the full large intestine of all pigs was 5.2 lb. with a standard deviation of 1.54 lb. The deviation from the mean was -.9, -.6, 0.1 and 1.2 lb. for the 150, 180, 210 and 240 lb. groups, respectively. The details of the breed x sex interaction are reported in table 6.

TABLE 6. MEANS FOR THE BREED X SEX INTERACTION FOR FULL LARGE INTESTINE WEIGHT

Breed	Sex	
	Females	Barrows
Yorkshire	6.07	4.79
Hampshire	4.66	5.16

The Yorkshire females had a greater full large intestine weight than the Yorkshire barrows. However, the Hampshire barrows had a heavier full large intestine weight than the Hampshire females.

Data for the empty large intestine weight revealed significant differences due to weight ($P < .01$) and two interactions, weight x breed ($P < .05$) and breed x sex ($P < .05$). The over-all mean for the empty large intestine weight was 2.94 lb. with a standard deviation of 0.69 lb. The means were 2.50, 2.67, 3.08 and 3.54 lb. for the 150, 180, 210 and 240 lb. groups, respectively. The means for the weight x breed interaction are listed in table 7.

TABLE 7. MEANS FOR THE WEIGHT X BREED INTERACTION FOR EMPTY LARGE INTESTINE WEIGHT

Breed	Weight, lb.			
	150	180	210	240
Yorkshire	2.21	2.74	3.00	3.88
Hampshire	2.79	2.61	3.15	3.20

The empty large intestine weight was greatest in the Yorkshire breed as compared to the Hampshires in the 180 and 240 lb. groups. The Hampshires recorded the heaviest empty large intestine weight in the 150 and the 210 lb. groups. This interaction may have been due to considerably heavier empty large intestine weights in the Hampshire breed at the 150 lb. weight with the reverse being true at the 240 lb. weight. The differences between breeds were much less at both of the intermediate weights. Table 8 lists the means for the breed x sex interaction.

TABLE 8. MEANS FOR THE EMPTY LARGE INTESTINE WEIGHT FOR THE BREED X SEX INTERACTION

Breed	Sex	
	Females	Barrows
Yorkshire	3.17	2.74
Hampshire	2.81	3.06

The Yorkshire females had heavier empty large intestine weights than the Yorkshire barrows; conversely, the Hampshire barrows showed a greater empty large intestine weight than the Hampshire females.

Significant differences ($P < .05$) for weight, breed and the breed x sex interaction were noted for the weight of the large intestine contents. The contents of the large intestine may be one of the factors affecting dressing percent. The weights of the large intestine contents were 1.76, 2.03, 1.96 and 2.93 lb. for the 150, 180, 210 and 240 lb. groups, respectively. The analysis indicated the Yorkshires had a heavier large intestine content weight (2.47 lb.) as compared to the Hampshires (1.87 lb.). This difference was due largely to the difference noted in the females of the two breeds as the Yorkshire and Hampshire barrows were similar in mean large intestine content weight. Means for the breed x sex interaction are presented in table 9.

TABLE 9. MEANS FOR THE LARGE INTESTINE CONTENT WEIGHT FOR THE BREED X SEX INTERACTION

	Sex	
Breed	Females	Barrows
Yorkshire	2.89	2.00
Hampshire	1.73	2.04

The Yorkshire breed exhibited a higher large intestine content weight for the females, but the Hampshire breed displayed a greater content weight for the barrows as compared to the females.

The total ruffle fat weight was significantly ($P < .01$) influenced by weight groups. The over-all mean for the four weight groups was 2.59 lb. with a standard deviation of 0.56 lb. The 150, 180, 210 and 240 lb. groups showed means of 2.28, 2.29, 2.74 and 3.07 lb., respectively.

The total visceral contents were not significantly influenced by any of the variables considered. This was expected because the pigs were all held off feed 24 hours before slaughter.

Data for weight of leaf fat reveal significant ($P < .01$) differences due to weight groups. The combined mean was 3.58 lb. with a standard deviation of 0.12 lb. The means increased from 2.29 to 4.94 lb. for the 150 and 240 lb. groups, respectively.

The weight of the mesenteric fat increased significantly ($P < .01$) from 2.64 to 3.69 lb. for the 150 and 240 lb. groups, respectively, as live weight increased.

Carcass Evaluation

Analyses of variance for dressing percent, average carcass backfat, average carcass length and loin eye area are given in table 10. The results of this study indicated that dressing percent was significantly influenced by weight groups only. The total mean dressing percent was 72.5% with a standard deviation of 1.87%. The means were 71.2, 71.7, 73.2 and 73.8% for the 150, 180, 210 and 240 lb. groups,

TABLE 10. ANALYSES OF VARIANCE FOR DRESSING PERCENT, AVERAGE CARCASS BACKFAT, AVERAGE CARCASS LENGTH AND AVERAGE LOIN EYE AREA

		Mean squares			
Source	d.f.	Dressing percent	Average carcass backfat	Average carcass length	Average loin eye area
Weight	3	24.16**	0.33**	30.68**	3.80**
Breed	1	8.85	0.10	8.59**	2.63**
Sex	1	0.95	0.42**	1.34*	0.81*
Weight x breed	3	0.54	0.03	0.57	0.01
Weight x sex	3	0.38	0.02	0.33	0.13
Breed x sex	1	8.70	0.03	0.20	0.08
Residual	51	2.48	0.03	0.26	0.16
Total	63				

* $P < .05$.
** $P < .01$.

respectively. A relatively large increase in dressing percent was observed between 180 and 210 lb. indicating a change in body composition as pigs approach 200 lb.

The mean average carcass backfat measurement which was significantly ($P < .01$) influenced by weight and sex was 1.30 in. As expected, average backfat increased as live weight increased. The difference between the 150 and 180 lb. groups was 0.03 in. However, there was a considerable increase in backfat thickness (0.21 in.) between the 180 and 210 lb. group, with the 210 and 240 lb. groups having nearly the same average carcass backfat. The barrows had an average carcass backfat measurement of 1.38 in. compared to the gilts at 1.22 in. These results agree with those reported by Carpenter and King (1964) and Emerson *et al.* (1964).

Significant weight ($P < .01$), breed ($P < .01$) and sex ($P < .05$) differences were noted for average carcass length. The total mean for carcass length was 30.3 in. The weight group means increased by increments of 1.5, 0.9 and 0.9 in. from 28.5 in. for the 150 lb. weight group. The Yorkshires displayed a longer carcass (30.7 in.) than the Hampshires (29.9 in.). On the average the females (30.4 in.) were slightly longer than the barrows (30.1 in.). Charette (1961) and Emerson *et al.* (1964) demonstrated that gilts possessed greater carcass length than barrows.

Results of the analyses of variance support the findings of Emerson *et al.* (1964) and McCampbell and Baird (1961) who demonstrated that loin eye area increases with increases in live weight. The deviations from the over-all mean of 3.87 sq. in. were -.59, -.11, 0.13 and 0.58 in. for the 150 to 240 lb. groups, respectively. The Hampshire breed exhibited a larger loin eye area (4.07 sq. in.) as compared to the Yorkshires (3.67 sq. in.). Average loin eye area for the females was 3.98 sq. in. while the barrows had a 3.76 sq. in. loin eye area. Breidenstein et al. (1963) showed similar relationships between sexes regarding loin eye area.

The trimmed cut weights are used often when evaluating pork carcasses. The analyses of variance for average trimmed ham weight, average trimmed loin weight, average trimmed shoulder weight and average trimmed side weight are shown in table 11. The average trimmed ham weight was significantly influenced by weight ($P < .01$) and sex ($P < .05$). The means were 11.2, 13.0, 14.4 and 16.5 lb. for the 150, 180, 210 and 240 lb. groups, respectively. The combined mean was 13.8 lb. with a standard deviation of 0.21 lb. The females had a heavier trimmed ham weight (14.0 lb.) as compared to the barrows (13.6 lb.).

Significant weight and breed differences ($P < .01$) were noted for average trimmed loin weight. The total mean for the trimmed loin was 13.1 lb. with means ranging from 10.1 lb. for the 150 lb. group to 16.2 lb. for the 240 lb. group. The significant breed difference revealed that the Hampshires had heavier trimmed loin weights (13.3 lb.) than the Yorkshires (12.9 lb.).

Carcass contests often place considerable emphasis on the trimmed ham and loin expressed as a percent of chilled carcass weight. Trimmed ham weight increased as live weight increased but when this weight was

TABLE 11. ANALYSES OF VARIANCE FOR AVERAGE TRIMMED HAM WEIGHT, AVERAGE TRIMMED LOIN WEIGHT, AVERAGE TRIMMED SHOULDER WEIGHT AND AVERAGE TRIMMED SIDE WEIGHT

Source	d.f.	Mean squares			
		Average trimmed ham wt.	Average trimmed loin wt.	Average trimmed shoulder wt.	Average trimmed side wt.
Weight	3	80.32**	104.32**	49.14**	34.41**
Breed	1	0.21	9.11**	10.48**	4.33**
Sex	1	2.93*	2.27	0.04	9.34**
Weight x breed	3	0.08	1.08	0.42	0.97
Weight x sex	3	1.47	1.16	0.13	1.10
Breed x sex	1	1.38	0.18	2.93*	5.97**
Residual	51	0.55	0.65	0.71	0.52
Total	63				

* $P < .05$.
** $P < .01$.

expressed as a percent of carcass weight the percent trimmed ham decreased as live weight increased. The percent ham decreased from 20.15 to 18.64% for the 150 and 240 lb. groups, respectively. The trimmed loin weight also increased as live weight increased. However, when the trimmed loin was expressed as a percent of chilled carcass weight, it did not follow the same decreasing trend as the percent trimmed ham. The percent trimmed loin was 18.23, 18.67, 18.06 and 18.26% for the 150, 180, 210 and 240 lb. groups, respectively. The combined means for trimmed ham and loin percentages for the 150, 180, 210 and 240 lb. weight groups were 38.38, 38.52, 36.73 and 36.92%, respectively. The relatively large difference observed between 180 and 210 lb. weights agrees with observations noted earlier concerning measures of fatness.

Average trimmed shoulder weight was significantly influenced by weight ($P < .01$), breed ($P < .01$) and the breed x sex interaction ($P < .05$). The total mean for the trimmed shoulder weight was 11.7 lb. with a standard deviation of 1.77 lb. The means were 9.7, 11.0, 12.3 and 13.8 lb. for the 150, 180, 210 and 240 lb. groups, respectively. The Hampshire breed had the heaviest trimmed shoulder (12.1 lb.) when compared to the Yorkshires (11.3 lb.). The means for the breed x sex interaction are given in table 12.

The mean weights indicate that the females of the Hampshire breed had the heavier trimmed shoulder, whereas the barrows exhibited the heaviest trimmed shoulder in the Yorkshire breed.

TABLE 12. MEANS FOR THE BREED X SEX INTERACTION FOR TRIMMED SHOULDER WEIGHT

Breed	Sex	
	Females	Barrows
Yorkshire	11.09	11.47
Hampshire	12.33	11.85

The analyses of variance indicated that the average trimmed side weight was significantly influenced ($P < .01$) by weight, breed, sex and the breed x sex interaction. Sides from the 150, 180, 210 and 240 lb. weight groups had mean weights of 7.1, 7.8, 9.2 and 10.4 lb., respectively. The heaviest side weight was displayed by the Hampshires (8.9 lb.) as compared to the Yorkshires (8.4 lb.). The mean trimmed side weight for the females and barrows was 8.3 lb. and 9.0 lb., respectively. Table 13 lists the means for the breed x sex interaction.

TABLE 13. MEANS FOR THE BREED X SEX INTERACTION FOR AVERAGE TRIMMED SIDE WEIGHT

Breed	Sex	
	Females	Barrows
Yorkshire	8.29	8.44
Hampshire	8.20	9.58

Yorkshire females had a slight advantage over Hampshire females in trimmed side weight, whereas among the barrows the Hampshires produced the largest trimmed side.

Another criterion used to evaluate carcass meatiness is the amount of edible portion (E.P.). Trimmed weights include some additional fat trim and bone; however, the E.P. weight is composed only of the useful lean.

The analyses of variance for average E.P. weight of the ham, loin, shoulder, side, bone cuts, jowl and percent E.P. of the carcass are listed in table 14. The mean E.P. weight of the ham was 11.0 lb. and was significantly influenced by weight ($P < .01$), sex ($P < .01$) and the breed x sex interaction ($P < .05$). As live weight increased, the E.P. weight of the ham also increased from 9.1 to 13.0 lb. for the 150 and 240 lb. groups, respectively. The females had higher average E.P. ham weights (11.3 lb.) than the barrows (10.8 lb.). The means for the interaction are listed in table 15.

The Hampshire females had a much higher E.P. ham weight than the Yorkshire females. In contrast the Yorkshire barrows displayed only a slightly greater E.P. weight than the Hampshire barrows.

Average E.P. weight of the loin was significantly influenced ($P < .01$) by weight and breed. The loin E.P. means were 7.9, 9.7, 11.0 and 12.8 lb. for the 150, 180, 210 and 240 lb. groups, respectively. Hampshires had significantly greater loin E.P. weights than the Yorkshires with means of 10.8 and 9.9 lb., respectively. Here again, in accordance with trimmed ham and loin weights, the pigs which recorded the heaviest live weight recorded the heaviest ham and loin E.P. Also, in agreement with the trimmed cuts as reported earlier, the E.P. when expressed as a percent of chilled carcass weight, decreased as live

TABLE 14. ANALYSES OF VARIANCE FOR AVERAGE E.P. WEIGHT OF THE HAM, LOIN, SHOULDER, SIDE, BONE CUTS, JOWL AND PERCENT E.P. OF CARCASS

		Mean squares						
Source	d.f.	Average E.P. wt. ham	Average E.P. wt. loin	Average E.P. wt. shoulder	Average E.P. wt. side	Average E.P. wt. bone cuts	Average E.P. wt. jowl	Percent E.P. of carcass
Weight	3	42.80**	70.58**	49.40**	33.82**	3.33**	3.94**	23.20**
Breed	1	0.74	13.46**	4.49*	0.68	0.00	0.01	9.00
Sex	1	3.75**	0.87	0.02	0.58	0.16	0.08	45.90**
Weight x breed	3	0.15	0.59	1.27	0.23	0.03	0.17	8.34
Weight x sex	3	1.03	0.89	0.23	0.34	0.02	0.04	16.60*
Breed x sex	1	2.44*	0.08	2.05	0.88	0.00	0.39	31.08**
Residual	51	0.46	0.46	0.82	0.42	0.07	0.12	5.00
Total	63							

* $P < .05$.
** $P < .01$.

TABLE 15. MEANS FOR THE BREED X SEX INTERACTION FOR E.P. WEIGHT OF THE HAM

Breed	Sex	
	Females	Barrows
Yorkshire	10.96	10.87
Hampshire	11.57	10.69

weight increased. The combined means for E.P. ham and loin as percentages of carcass weight for the 150, 180, 210 and 240 lb. groups were 30.51, 30.60, 29.38 and 29.10%, respectively. The large difference, as noted earlier, was observed between the 180 and 210 lb. weight groups.

Weight and breed had a significant ($P < .01$) influence on the average E.P. weight of the shoulder. The deviations from the mean of 10.4 lb. were -1.9, -.8, 0.3 and 2.3 lb. for the 150, 180, 210 and 240 lb. groups, respectively. Hampshires produced 0.5 lb. more E.P. of the shoulder than Yorkshires.

The E.P. weights of the side, the bone cuts and the jowl were significantly influenced ($P < .01$) only by weight groups. As expected, the weight of the variables increased with the increase in live weight.

The percent E.P. of a carcass is one of the most valuable estimates of carcass merit. This variable was significantly influenced by weight ($P < .01$), sex ($P < .01$), weight x sex ($P < .05$) and the breed x sex interaction ($P < .01$). The mean for the entire experiment was 60.2% with a standard deviation of 2.77%. Means for the various weight groups did not follow a definite linear pattern. The means were 60.9, 60.9, 58.8 and 59.5% for the 150, 180, 210 and 240 lb. groups, respectively. The sex difference showed a mean of 60.8% for the females as compared to 59.3% for the barrows. Table 16 lists the means for the weight x sex interaction.

TABLE 16. MEANS FOR THE WEIGHT X SEX INTERACTION FOR PERCENT E.P. OF THE CARCASS

	Weight, lb.			
Sex	150	180	210	240
Females	60.86	61.24	60.61	60.28
Barrows	61.95	59.54	57.00	58.73

The means of this interaction indicate the females had the highest percent E.P. in all the weight groups except the 150 lb. group. Thus, the barrows excelled the gilts only in the light weight group.

The means for the breed x sex interaction are listed in table 17.

TABLE 17. MEANS FOR THE BREED X SEX INTERACTION FOR PERCENT E.P. OF THE CARCASS

	Sex	
Breed	Females	Barrows
Yorkshire	59.93	59.63
Hampshire	60.69	58.98

Table 17 indicated the Hampshire females had a higher percent E.P. than the Yorkshire females. On the other hand, the Yorkshire barrows had a higher percent E.P. than the Hampshire barrows.

The analyses of variance for bone weight, percent bone, fat weight, percent fat, foot weight, lean trim weight and percent lean trim of the carcass are shown in table 18.

The average bone weight per side and the percent bone per carcass was significantly influenced only by weight groups. The total mean for average bone weight was 8.42 lb. The bone weight ranged from 7.4 lb. to 9.6 lb. per side for the 150 and 240 lb. groups, respectively. The bone weight when expressed as a percent of chilled carcass decreased from 13.2% for the 150 lb. group to 10.9% for the 240 lb. group with an over-all mean of 11.9%.

The analyses of variance indicated that weight ($P < .01$), sex ($P < .01$) and the weight x sex interaction ($P < .05$) significantly influenced the average fat weight per side and average percent fat per carcass. As expected, both the fat weight and percent fat increased with increasing live weight. The over-all means for fat weight were 13.2, 15.9, 21.3 and 24.3 lb., whereas the means for percent fat were 24.2, 24.1, 27.6 and 27.5% for the 150, 180, 210 and 240 lb. groups, respectively. Both sets of means indicated a relatively large gap between the 180 and 210 lb. weight groups. The most pronounced break was in the percent fat of the carcass. The same relationship among weight group means has been observed for other variables including carcass backfat, percent E.P. and dressing percent. These data suggest that an alteration in the relative composition of live weight gains occurred in or near the 180 to 210 lb. weight interval. More of the gain was made up of fat in the higher weight groups. Comparisons

TABLE 18. ANALYSES OF VARIANCE FOR AVERAGE BONE WEIGHT PER SIDE, AVERAGE PERCENT BONE PER CARCASS, AVERAGE FAT WEIGHT PER SIDE, AVERAGE PERCENT FAT PER CARCASS, AVERAGE FOOT WEIGHT PER SIDE, AVERAGE WEIGHT LEAN TRIM PER SIDE AND AVERAGE PERCENT LEAN TRIM OF THE CARCASS

		Mean squares						
Source	d.f.	Average bone wt. per side	Average percent bone per carcass	Average fat wt. per side	Average percent fat per carcass	Average foot wt. per side	Average wt. lean trim per side	Average percent lean trim of carcass
Weight	3	0.15**	0.17**	413.30**	69.94**	1.53**	123.79**	4.35
Breed	1	0.00	0.01	6.03	0.68	0.03	5.76	4.36
Sex	1	0.00	0.00	78.65**	93.61**	0.00	1.59	0.88
Weight x breed	3	0.02	0.04	4.69	5.52	0.04	0.14	1.38
Weight x sex	3	0.01	0.03	16.97*	24.72*	0.01	1.22	1.12
Breed x sex	1	0.00	0.00	10.42	23.77	0.00	0.47	0.00
Residual	51	0.01	0.02	5.23	6.29	0.04	2.45	2.63
Total	63							

* $P < .05$.
** $P < .01$.

using either fat weight per side or percent fat per carcass demonstrated that barrows (19.8 lb., 26.9%) were fatter than gilts (17.5 lb., 24.3%).

Table 19 gives the means for the weight x sex interaction for fat weight per side.

TABLE 19. MEANS FOR THE WEIGHT X SEX INTERACTION FOR FAT WEIGHT PER SIDE

Sex	Weight, lb.			
	150	180	210	240
Females	13.60	14.60	19.38	22.78
Barrows	12.83	17.13	23.19	26.07

The means for this interaction indicated that the females showed the lowest fat weight in all weight groups except the 150 lb. group.

The means for the weight x sex interaction for percent fat per carcass are listed in table 20.

TABLE 20. MEANS FOR THE WEIGHT X SEX INTERACTION FOR PERCENT FAT OF THE CARCASS

Sex	Weight, lb.			
	150	180	210	240
Females	24.31	22.48	25.24	26.08
Barrows	23.20	25.72	29.94	28.91

This interaction shows the same results as the preceding interaction for fat weight. The 150 lb. group was the only weight group in which the females showed a higher percent fat than the barrows.

Both the average foot weight per side and the average lean trim weight per side were significantly influenced (P .01) only by weight groups. The total mean foot weight per side was 1.92 lb. The means ranged from 1.55 lb. for the 150 lb. group to 2.31 lb. for the 240 lb. group. The over-all mean for lean trim weight per side was 16.1 lb. with means of 13.4, 14.6, 16.9 and 19.6 lb. for the 150, 180, 210 and 240 lb. groups, respectively. The percent lean trim per side was not significantly influenced by weight, sex or breed.

The location for the actual measurements of the variables to be discussed next were referred to earlier in this text (figures 1, 2 and 3). Analyses of variance for average fat thickness and lean thickness of the ham, shoulder and loin are shown in table 21. The average fat thickness of the ham was significantly influenced by weight (P .01) and the weight x sex interaction (P .05). The means were 0.54, 0.58, 0.74 and 0.79 in. for the 150, 180, 210 and 240 lb. groups, respectively. The means for the weight x sex interaction are listed in table 22.

The barrows showed the greatest mean fat thickness for the 180, 210 and 240 lb. groups. The females displayed the greatest fat thickness for the 150 lb. group.

The average lean thickness of the ham was significantly influenced by weight groups (P .05). The lean thickness of the ham for the entire experiment was 2.75 in. The lean thickness ranged from 2.62 in. for the 150 lb. group to 2.86 in. for the 240 lb. group.

TABLE 21. ANALYSES OF VARIANCE FOR AVERAGE FAT THICKNESS AND LEAN THICKNESS OF THE HAM, SHOULDER AND LOIN

		Mean squares					
Source	d.f.	Average fat thickness ham in.	Average lean thickness ham in.	Average fat thickness shoulder in.	Average lean thickness shoulder in.	Average fat thickness loin in.	Average lean thickness loin in.
Weight	3	0.22**	0.18*	0.21**	3.30**	0.71**	0.19**
Breed	1	0.08	0.13	0.00	0.29	0.01	0.77**
Sex	1	0.02	0.12	0.54**	0.31	0.96**	0.00
Weight x breed	3	0.01	0.01	0.00	0.09	0.06	0.01
Weight x sex	3	0.08*	0.02	0.02	0.14	0.10	0.00
Breed x sex	1	0.02	0.02	0.04	0.01	0.07	0.01
Residual	51	0.02	0.06	0.03	0.15	0.04	0.02
Total	63						

* $P < .05$.
** $P < .01$.

TABLE 22. MEANS FOR THE WEIGHT X SEX INTERACTION FOR THE AVERAGE FAT THICKNESS OF THE HAM

Sex	Weight, lb. 150	180	210	240
Females	0.61	0.63	0.68	0.77
Barrows	0.48	0.67	0.81	0.81

The average fat thickness of the shoulder was significantly influenced ($P < .01$) by weight and sex. The total mean was 0.83 in. with a range of 0.76 in. to 0.95 in. for the 150 lb. and 240 lb. groups, respectively. The males had 0.18 in. more fat than the females at the shoulder measurement. The lean thickness of the shoulder was also significantly influenced by weight. The lean thickness ranged from 3.11 in. for the 150 lb. group to 4.16 in. for the 240 lb. group.

The average fat thickness of the loin was significantly influenced ($P < .01$) by weight and sex. The total mean was 1.20 in. with a standard deviation of 0.31 in. The means were 1.01, 1.03, 1.34 and 1.43 in. for the 150, 180, 210 and 240 lb. groups, respectively. Previous fat measures indicated that the females were the leanest. The fat measurement of the loin was no exception as the females showed a fat thickness of 1.08 in. while the males had 1.33 in. fat over the loin.

The analyses of variance demonstrated that lean thickness of the loin was significantly influenced ($P < .01$) by weight and breed. The lean thickness ranged from 1.48 in. for the 150 lb. group to 1.74 in. for the 240 lb. group. The significant breed difference indicated the

Hampshire loin lean thickness was 1.73 in. and the Yorkshire loin lean thickness was 1.51 in.

Correlations

The relationship between offal weights and carcass composition was stated as an objective of this study. Table 23 summarizes these relationships in the form of correlation coefficients.

Prior to the consideration of carcass composition, the influence of offal weights on total body composition was observed by correlating the offal data with dressing percent. Only leaf fat, mesenteric fats (caul and ruffle fat) and spleen weights were significantly correlated with dressing percent. The various gastro-intestinal tract component weights were characterized by consistently low correlations with dressing percent.

Leaf fat weight was highly significantly ($P < .01$) related to percent fat with a simple correlation of 0.69. Percent fat was also significantly correlated with viscera weight ($P < .01$), empty stomach weight ($P < .05$) and total mesenteric fat weight ($P < .05$). The only significant correlation with percent E.P. was the negative relationship ($r = -.55$) between it and leaf fat weight.

In general, the weights and measurements of the carcass or its components demonstrated negative or low positive correlation coefficients with percent E.P. (table 24). However, when ham and loin are expressed as a percent of chilled carcass, the relationship becomes positive and highly significant. On the other hand, the correlation coefficients between percent fat and carcass weights and measures were

TABLE 23. CORRELATION COEFFICIENTS BETWEEN VARIOUS OFFAL WEIGHTS AND CARCASS COMPOSITION

	Dressing percent	Percent fat	Percent E.P.
Viscera wt.	-.11	0.35**	-.19
Pluck wt.	0.22	0.18	-.00
Spleen wt.	0.33*	0.12	-.06
Caul fat wt.	0.29*	0.19	-.08
Full stomach wt.	0.05	0.24	-.10
Empty stomach wt.	0.21	0.32*	-.16
Stomach contents wt.	-.07	0.16	-.05
Full small intestine wt.	-.07	0.18	-.17
Empty small intestine wt.	-.07	0.14	-.15
Small intestine contents wt.	-.04	0.16	-.12
Full large intestine wt.	-.07	0.21	-.06
Empty large intestine wt.	-.07	0.21	-.09
Large intestine contents wt.	-.19	0.12	-.01
Total ruffle fat wt.	0.34*	0.25	-.17
Total visceral contents wt.	-.17	0.18	-.07
Total mesenteric fat wt.	0.38**	0.28*	-.17
Leaf fat wt.	0.49**	0.69**	-.55**

* 0.27 needed at the 5% level of significance.
** 0.35 needed at the 1% level of significance.

TABLE 24. CORRELATION COEFFICIENTS BETWEEN VARIOUS CARCASS DATA AND THE PERCENT E.P. AND THE PERCENT FAT

	Percent E.P.	Percent fat
Dressing percent	-.25	0.41**
Backfat	-.62**	0.84**
Length	-.35**	0.43**
Loin eye area	0.01	0.20
Bone weight	-.22	0.60**
Percent bone	0.25	-.48**
Trimmed ham weight	-.14	0.26
Trimmed loin weight	-.21	0.38**
Trimmed shoulder weight	-.15	0.30*
Trimmed side weight	-.49**	0.69**
Fat thickness of ham	-.60**	0.67**
Lean thickness of ham	0.03	0.10
Fat thickness of loin	-.72**	0.80**
Lean thickness of loin	0.09	0.13
Fat thickness of shoulder	-.53**	0.75**
Lean thickness of shoulder	-.08	0.20
E.P. weight of ham	-.03	0.18
E.P. weight of loin	-.18	0.39**
E.P. weight of shoulder	0.15	0.29*
E.P. weight of side	-.29*	0.50**
Percent trimmed ham	0.67**	-.83**
Ham E.P. as percent of chilled carcass	0.78*	-.87**
Percent trimmed loin	0.58**	-.59**
Loin E.P. as percent of chilled carcass	0.54**	-.36**
Percent trimmed ham and loin	0.76**	-.88**
Ham and loin E.P. as percent of chilled carcass	0.85**	-.82**

* 0.27 needed at the 5% level of significance.
** 0.35 needed at the 1% level of significance.

positive and relatively high. Trimmed or E.P. weights expressed as a percent of the carcass were significantly and negatively related to percent fat. The significant positive relationships between weight or size of the carcass or its components and percent fat support the results of Buck (1963) who indicated that heavier hogs are fatter. When the data are expressed as a percent of carcass weight, some adjustment is made for differences in the live weight.

Percent E.P. of the ham and loin had the highest relationship (r = 0.85) with percent E.P. Variables also having high relationships with percent E.P. were percent E.P. of ham, percent trimmed ham and loin and percent trimmed ham. The variables most highly negatively correlated with percent fat were percent trimmed ham and loin (r = -.88) and percent E.P. of the ham (r = -.87). Other good indicators of percent fat were percent trimmed ham (r = -.83) and percent ham and loin E.P. (r = -.82). The above correlations indicate that the ham expressed as a percent of the carcass is more highly related to carcass composition than the loin expressed as a percent. These findings agree with the work of Henry et al. (1963) and Stouffer and Burgkart (1965) who stated that the ham is closely correlated with carcass composition.

SUMMARY AND CONCLUSIONS

This study evaluated various quantity components of the carcass as influenced by the major variable, live weight. The 64 animals were divided equally into four weight groups according to breed and sex. They were slaughtered at weights of 150, 180, 210 and 240 lb. Weights of various offal items and the gastro-intestinal tract contents were collected during the slaughter procedure. Both sides of each carcass were separated into an edible portion (E.P.), fat and bone portion.

As live weight increased, rate of daily gain increased. There was a slaughter age difference of 59 days between the 150 and 240 lb. group. The mean for the entire experiment indicated that the gilts were 16 days older than the barrows.

Dressing percent, which increased with live weight, was significantly influenced only by weight groups. The barrows had 0.16 in. more backfat and 0.22 sq. in. less loin eye area than the gilts. As expected, average carcass backfat, carcass length and loin eye area increased as live weight increased.

The trimmed cut weights, as expected, were all significantly influenced by live weight. However, the trimmed ham and the trimmed side weights were the only trimmed weights which were significantly influenced by sex. Results indicated that the gilts had the heaviest trimmed ham weight and a lighter trimmed side weight. Weights of the average trimmed loin, shoulder and side were significantly influenced by breed. In each case the Hampshires showed the heaviest weights.

The same relationships as discussed for trimmed weights held true for the E.P. weights of the ham, loin and shoulder.

The percent E.P. of the carcass has been discussed as one of the most valuable estimates of carcass meatiness. The means of this variable decreased from 60.9% for the 150 lb. group to 59.5% for the 240 lb. group. Here again, as with many other measures of leanness, the gilts had 1.6% more E.P. than the barrows.

Percent bone per carcass was significantly influenced only by weight groups. The values decreased from 13.2% for the 150 lb. group to 10.9% for the 240 lb. group.

Results from the analyses of variance indicated that percent fat was significantly influenced by weight and sex. The values for percent fat were 24.2, 24.1, 27.6 and 27.5% for the 150, 180, 210 and 240 lb. groups, respectively. The barrows averaged 2.6% more fat per carcass than the females. The means of several variables in this study, average fat weight per side, percent fat, carcass backfat, percent E.P. and dressing percent, can be divided into pairs with a large gap between the 180 and 210 lb. weight groups. These data suggest that a change in body composition occurs in or near the 180 to 210 lb. weight groups.

Evaluation of the slaughter data indicated no highly significant correlations between dressing percent and various organ or contents weights. However, several measures of fatness were correlated with dressing percent.

Results from other simple correlations indicate a high relationship between backfat measurements and percent fat. It was also evident from the simple correlations that the ham (trimmed or E.P.) expressed as a percent of carcass weight is highly related to carcass composition.

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APPENDIX

TABLE 1. MEANS LISTED ACCORDING TO BREED AND SEX

Variable	Breed		Sex	
	Yorkshire	Hampshire	Females	Barrows
Rate of daily gain (lb.)	1.12	1.17	1.09	1.20
Animal age at slaughter (days)	185.4	178.9	190.0	174.3
Head wt.	10.40	10.36	10.42	10.34
Viscera wt.	18.04	18.01	17.87	18.18
Pluck wt.	3.71	4.06	3.88	3.89
Liver wt.	2.80	3.08	2.94	2.94
Spleen wt.	0.36	0.39	0.39	0.35
Caul fat wt.	0.46	0.54	0.50	0.50
Full stomach wt.	1.74	1.73	1.69	1.78
Empty stomach wt.	1.35	1.39	1.38	1.36
Stomach contents wt.	0.39	0.37	0.31	0.45
Full small intestine wt.	3.82	3.82	3.71	3.93
Empty small intestine wt.	3.26	3.09	3.09	3.26
Small intestine contents wt.	0.53	0.71	0.60	0.64
Full large intestine wt.	5.43	4.91	5.36	4.97
Empty large intestine wt.	2.96	2.94	2.99	2.90
Large intestine contents wt.	2.47	1.87	2.31	2.02
Total ruffle fat wt.	2.54	2.65	2.51	2.68
Total visceral contents wt.	3.40	2.92	3.20	3.12
Leaf fat wt.	3.75	3.42	3.44	3.72
Total mesenteric fat wt.	3.01	3.19	3.02	3.17
Dressing percent	72.11	72.85	72.36	72.60
Average carcass backfat (in.)	1.34	1.26	1.22	1.38
Average carcass length (in.)	30.65	29.92	30.43	30.14
Average loin eye area (sq. in.)	3.67	4.07	3.98	3.76
Average trimmed ham wt.	13.71	13.83	13.98	13.55
Average trimmed loin wt.	12.74	13.50	13.31	12.93
Average trimmed shoulder wt.	11.28	12.09	11.71	11.66
Average trimmed side wt.	8.37	8.89	8.25	9.01
Average E.P. wt. ham	10.92	11.13	11.27	10.78
Average E.P. wt. loin	9.87	10.79	10.45	10.21
Average E.P. wt. shoulder	10.12	10.65	10.40	10.37
Average E.P. wt. side	7.54	7.75	7.55	7.74
Average E.P. wt. bone cuts	2.05	2.07	1.94	2.00
Average E.P. wt. jowl	1.60	1.48	1.59	1.49
Percent E.P. per carcass	59.76	60.53	60.80	59.38
Average bone wt. per side	8.40	8.45	8.39	8.46
Average percent bone per carcass	12.00	11.81	11.90	11.92
Average fat wt. per side	18.39	18.91	17.25	20.05
Average percent fat per carcass	25.84	25.63	24.53	26.94
Average foot wt. per side	1.89	1.95	2.01	1.83

TABLE 1 CONTINUED

Variable	Breed		Sex	
	Yorkshire	Hampshire	Females	Barrows
Average wt. lean trim per side	15.72	16.54	16.49	15.77
Average fat thickness ham (in.)	0.70	0.64	0.68	0.60
Average lean thickness ham (in.)	2.71	2.80	2.71	2.80
Average fat thickness shoulder (in.)	0.82	0.84	0.74	0.92
Average lean thickness shoulder (in.)	3.67	3.81	3.81	3.67
Average fat thickness loin (in.)	1.19	1.21	1.08	1.33
Average lean thickness loin (in.)	1.51	1.73	1.63	1.61
Percent trimmed ham of chilled carcass	19.56	19.09	19.69	18.96
Percent trimmed loin of chilled carcass	18.09	18.52	18.66	17.95
Percent E.P. ham of chilled carcass	15.59	15.42	15.91	15.10
Percent E.P. loin of chilled carcass	13.99	14.76	14.62	14.15
Percent trimmed ham and loin of chilled carcass	37.66	37.62	38.37	36.91
Percent E.P. ham and loin of chilled carcass	29.60	30.20	30.53	29.26

TABLE 2. MEANS LISTED ACCORDING TO WEIGHT GROUPS

Variable	Weight groups, lb. 150	180	210	240
Rate of daily gain (lb.)	1.09	1.08	1.20	1.20
Animal age at slaughter (days)	151.75	178.50	187.25	211.06
Head wt.	8.48	9.95	10.97	12.05
Viscera wt.	15.69	16.76	18.54	21.12
Pluck wt.	3.30	3.92	4.06	4.26
Liver wt.	2.69	2.81	2.97	3.29
Spleen wt.	0.29	0.36	0.38	0.47
Caul fat wt.	0.36	0.48	0.54	0.61
Full stomach wt.	1.41	1.70	1.78	2.04
Empty stomach wt.	1.11	1.34	1.41	1.60
Stomach contents wt.	0.29	0.36	0.43	0.44
Full small intestine wt.	3.71	3.61	4.00	3.96
Empty small intestine wt.	3.13	3.04	3.27	3.25
Small intestine contents wt.	0.53	0.56	0.71	0.68
Full large intestine wt.	4.27	4.64	5.34	6.40
Empty large intestine wt.	2.50	2.67	3.08	3.54
Large intestine contents wt.	1.76	2.03	1.96	2.93
Total ruffle fat wt.	2.28	2.29	2.74	3.07
Total visceral contents wt.	2.58	2.94	3.10	4.05
Leaf fat wt.	2.29	3.11	3.98	4.94
Total mesenteric fat wt.	2.64	2.77	3.28	3.68
Dressing percent	71.18	71.74	73.19	73.81
Average carcass backfat (in.)	1.16	1.19	1.40	1.44
Average carcass length (in.)	28.51	29.99	30.86	31.76
Average loin eye area (sq. in.)	3.28	3.76	4.00	4.45
Average trimmed ham wt.	11.19	13.03	14.35	16.51
Average trimmed loin wt.	10.14	12.27	13.89	16.18
Average trimmed shoulder wt.	9.70	10.98	12.27	13.79
Average trimmed side wt.	7.13	7.75	9.24	10.38
Average E.P. wt. ham	9.14	10.43	11.58	12.96
Average E.P. wt. loin	7.89	9.67	11.00	12.81
Average E.P. wt. shoulder	8.49	9.64	10.72	12.65
Average E.P. wt. side	6.04	6.86	8.03	9.50
Average E.P. wt. bone cuts	1.49	1.95	2.18	2.54
Average E.P. wt. jowl	0.98	1.40	1.57	2.17
Percent E.P. per carcass	60.91	60.89	58.81	59.50
Average bone wt. per side	7.43	8.20	8.63	9.61
Average percent bone per carcass	13.23	12.50	11.24	10.87
Average fat wt. per side	13.19	15.88	21.25	24.31
Average percent fat per carcass	24.22	24.10	27.59	27.49
Average foot wt. per side	1.55	1.83	2.00	2.31
Average wt. lean trim per side	13.42	14.60	16.94	19.56
Average fat thickness ham (in.)	0.54	0.58	0.74	0.79

TABLE 2 CONTINUED

Variable	Weight groups, lb. 150	180	210	240
Average lean thickness ham (in.)	2.62	2.71	2.82	2.86
Average fat thickness shoulder (in.)	0.76	0.70	0.89	0.95
Average lean thickness shoulder (in.)	3.11	3.74	3.95	4.16
Average fat thickness loin (in.)	1.01	1.03	1.34	1.43
Average lean thickness loin (in.)	1.48	1.61	1.65	1.74
Percent trimmed ham of chilled carcass	20.15	19.84	18.67	18.64
Percent trimmed loin of chilled carcass	18.23	18.67	18.06	18.26
Percent E.P. ham of chilled carcass	16.41	15.88	15.08	14.64
Percent E.P. loin of chilled carcass	14.09	14.70	14.29	14.45
Percent trimmed ham and loin of chilled carcass	38.38	38.52	36.73	36.92
Percent E.P. ham and loin of chilled carcass	30.51	30.60	29.38	29.10