THE RELATION OF K^{40} NET COUNT AND PROBE TO BODY COMPOSITION CHANGES IN GROWING AND FINISHING SWINE

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CHAPTER I

INTRODUCTION

The increased emphasis placed on muscling in meat animals in recent times has brought about a greater need for more accurate methods of evaluating live animals with respect to muscle development. Early methods for estimating meat animal composition were based largely on physical separation of the tissues of the carcasses of animals. In more recent years, more and more emphasis has been placed on the development of efficient, non-destructive methods for estimating body composition.

It has been demonstrated that animals within a specie of similar ages and weights differ markedly in the ratios of lean to fat and lean to bone. These differences have been observed within breeds as well as among family lines within breeds. Since most carcass traits are moderately to highly heritable, effective tools for live animal appraisal are needed to more accurately assess differences in body composition among animals for breeding as well as for market purposes.

Perhaps the most reliable means of sire evaluation is the progeny test. This method is quite time consuming and expensive. A reliable, non-destructive method of evaluation for muscling could enable the breeder to improve the effectiveness of the selection process, thereby hastening the rate of genetic improvement for this carcass trait. One such non-destructive method developed for the determination of differences in body composition in meat animals is the K^{40} whole-body scintillation counter. The development of whole-body counters, such as the O.S.U. whole-body counter, has made it possible to measure radiation energy arising from the radioactive isotope potassium-40 (which emits a low energy gamma ray) and thus to predict muscling in meat animals in a non-destructive manner.

There are two properties of potassium that make its quantitative measurement in animals and their tissues useful and practical for this purpose. First, potassium appears to be relatively independent of body fat and, therefore, makes up a relatively constant proportion of the fat-free body when considered within species and age groups. Secondly, the measurement of potassium is possible because a small but constant amount of all potassium is radioactive and emits radiation energy which can be measured.

Previous research at the Oklahoma Agricultural Experiment Station has been conducted with swine uniform in age and weighing between 220 and 240 pounds in order to subject the O.S.U. K^{40} whole-body counter to critical tests of repeatability and tests designed to measure its efficiency as an estimator of muscling among market weight hogs. Results from these studies have led to the development of prediction equations which are currently used to evaluate the fat-free lean in 220 to 240 pound hogs. However, limited research has been conducted with the O.S.U. whole-body counter in an effort to determine its capability to predict muscle content in swine of younger ages and lighter weights. An earlier study involving pigs slaughtered at 100, 150, 200, 250, and 300 pounds was conducted using the cattle counting configuration in the whole-body counting chamber. An improvement in counting efficiency is realized when the ratio of sample to detector volume is increased. Consequently, a new detector arrangement was designed to position the pigs as close to the detectors as possible, thereby increasing the ratio of sample to detector volume.

The objectives of this study were:

1. To observe any trends in the association between certain live measurements obtained from two different techniques (potassium-40 as determined by modified O.S.U. whole-body counter and live backfat probe) and various carcass measurements at five different slaughter weights (100, 150, 200, 250, and 300 pounds).

2. To determine the changes in composition with respect to muscle, fat, and bone in pigs slaughtered at five different weights and ages.

3. To study the gross and chemical composition of certain muscle systems from pigs of the five above stated slaughter weights and to evaluate associations between these muscle weights and total carcass lean at each slaughter weight.

CHAPTER II

LITERATURE REVIEW

Introduction

The search for an accurate method of estimating the composition of meat animals has resulted in the development and evaluation of various tools designed for this purpose. Early attempts to estimate carcass composition generally consisted of the analysis of a small portion of the carcass. Such methods included various carcass measurements (loin eye area, length, backfat), certain bone and muscle relationships, specific gravity measurements, and the actual physical dissection of the carcass or portions of it. Some of these methods appeared to be reliable predictors of carcass composition, but all were laborious and required the actual slaughtering of animals. In more recent years, researchers have sought for more efficient ways of estimating body composition that would not require the sacrificing of animals. Researchers have developed several methods including biopsy techniques, ultrasonics, and photogrammetry to accomplish this task.

Another non-destructive instrument that has been developed in recent years for the evaluation of live animal composition is the K^{40} whole-body counter. The development of whole-body counters, such as the O.S.U. whole-body counter, has made it possible to measure gamma radiation arising from the element potassium and thus to predict muscling in meat animals in a non-destructive manner.

Potassium is the principle cation found in the intracellular fluid of mammals and is present as a relatively constant proportion of this fluid fraction for a given species (Manery, 1954; and Conway, 1957).

Anderson (1959) stated, "Since the concentration of potassium in living cells is held constant by homeostatic processes, a determination of potassium content is equivalent to determination of cellular mass. . . Applications to the meat industry are based on this proportionality between potassium and the mass of lean tissue." Since most of the intracellular fluid is present in muscle tissue and organs of the body, it is reasoned that the higher the proportion of muscle tissue in an animal, the greater the quantity of potassium in that animal.

Principles of the K^{40} Technique

Potassium-40 is a naturally occurring radioisotope of potassium which has been found to constitute 0.0119 percent of all potassium (Kulwich, Fernstein, and Golumbic, 1960). This property of potassium is the basis of one of the two major principles on which the K^{40} whole-body counter was developed. This principle is further supported by Forbes (1963) and Ward, Johnson, and Tyler (1967) who reported that

K^{40} comprised 0.012 percent of all naturally occurring potassium. The spontaneous disintegrations of radioactive K^{40} atoms cause nuclear energy to be produced and this energy, in the case of K^{40}, is dissipated with the emission of beta and gamma particles from its nucleus. Since body density is only slightly greater than the density of water, a considerable proportion of gamma radiation from K^{40} passes out of the body of living animals. If suitable detection equipment is placed beside or around an animal, it then becomes possible to measure the animal's radioactivity, and with a suitable method of calibration, estimate the potassium content of the animal.

The second principle is based on the concept that a large percentage of the potassium in the body of a live animal is found in muscle. This second principle has instigated considerable research and has resulted in some conflicting reports.

Kirton _et al_. (1961) found 50 percent of the total body potassium of sheep to be in lean tissue. Kirton and Pearson (1963) reported a potassium concentration in separable fat of 0.082 percent while 11 percent of the potassium content of the carcass was in bone.

From a study involving 90 beef steers, Lohman and Norton (1968) reported that potassium was found in all steer tissues with trimmed lean comprising 53.4 percent, carcass bone 12.4 percent, the gastrointestinal tract 16.4 percent, and carcass adipose tissue 4.0 percent of the total body potassium. The gastrointestinal tract was found to be the most variable source of potassium, and carcass adipose potassium was reported to contribute very little to the variation in total body potassium.

Lawrie and Pomeroy (1963) concurred with Anderson (1959) that most potassium was mainly associated with the intracellular, nonfat phase in the body and that the quantity of potassium in the muscle tissue was constant. Pfau (1965) reported that 69 percent of the total body potassium was found in the muscle of swine; while Kirton, Gnaedinger, and Pearson (1963) found that pig carcasses contained 81 percent of the potassium in the empty body. Pfau and Kallistratos (1963) reported that 84 percent of the carcass potassium was in the muscle of swine. Similar results were reported by Stant, Martin, and Kessler (1969) who found 81 percent of the carcass potassium in the muscle of the pig. These reports indicate that although a large percentage of total body potassium is located in muscle, other components such as bone, fat, and the gastrointestinal tract may alter the precision of potassium based methods for predicting lean tissue in live animals.

Potassium Concentrations in the Tissues of Different Species of Animals

Rats

Lowry and coworkers (1942) studied the potassium level of rat thigh muscle in relation to the age of the rat. A small decrease in the potassium content of fat-free muscle was observed with increasing age. Mean values for mEq of potassium per kg of fat-free thigh muscle for rats aged 70, 153, 449, and 668 days were 113.3, 112.9, 110.3, and 107.0, respectively. A decrease of 5.6 percent in muscle potassium content occurred when comparing the oldest and youngest groups; however, the change in potassium concentration was gradual at the intermediate age levels.

Cheek and West (1955) studied the relationship of lean body mass (weight minus fat) to the total potassium content of 30 rat carcasses, and found a linear relationship between these two variables. Potassium content was determined by flame photometry, using aliquots of a solution containing the ash from 150 mg carcass sample from each animal. On the basis of these researchers' equation for the regression of total body potassium on lean body mass, each increase of 292 mg of potassium was associated with an increase of 100 g of lean body mass. The value of 292 mg of potassium per 100 g of lean body mass agrees quite closely with the average of 300 mg of potassium per 100 g of fat-free body tissue which Spray and Widdowson (1950) reported for adult rats.

Humans

Corsa and coworkers (1950) using the potassium-42 isotope found that 95 percent of the total human-body potassium was exchangeable. Muldowney, Crooks, and Bluhm (1957), using potassium-42 as a tracer, found a highly significant correlation (r = 0.90) between total exchangeable potassium and lean body mass in a study of 30 humans ranging in age from 18 to 81 years. Using the prediction equation developed from the study, the researchers found that for each increase of 289 mg in exchangeable potassium, lean body mass increased 100 g. Spray and Widdowson (1950) reported a value of 280 mg of potassium per 100 g of fat-free body tissue for a human adult. Forbes and Lewis (1956) reported potassium concentration values of four human adults and when expressed in terms of mg of potassium per 100 g of fat-free weight, the values ranged from 260 to 285, averaging 266 mg.

Poultry

Barlow and Manery (1954) studied the potassium content of muscle from young chicks (three to four days old) and adult hens. Breast muscle samples weighing 3 g for the hens and 1 g for the chicks were analyzed chemically. Adult hen muscle contained 98.3 mEq of potassium per kg of wet weight, which is equivalent to 384 mg of potassium per 100 g of muscle. Muscle from three to four day old chicks contained about one-half as much potassium, on a wet basis, as adult hen muscle. Karvis and Kare (1960) measured the potassium content of various tissues from White Leghorn chickens ranging from 1 to 463 days of age. Their results for breast muscle were somewhat similar to those of Barlow and Manery (1954), with breast muscle potassium values for young chicks (one to five days old) ranging from 29.7 to 58.9 mEq per kg of wet weight. The authors observed that at three to four weeks of age, relatively stable potassium levels were reached.

Sheep

Blaxter and Rook (1956) reported muscle values from 296 to 300 mg of potassium per 100 g of muscle for two sheep. Lohman *et al*. (1965), in a study involving 27 lambs averaging 73.6 pounds, reported that the whole body contained 0.21 percent potassium while the carcass contained 0.25 percent. Mounib and Evans (1960) measured the potassium content of five high-potassium type aged ewes and five low-potassium type ewes and found the values to be 0.432 and 0.425 percent, respectively. The potassium content of the blood was used to characterize the two types of ewes involved in the experiment.

Cattle

Blaxter and Rook (1956) analyzed for tissue potassium levels in eight Ayrshire cattle which ranged from 1 to 300 weeks in age. Tissue samples weighing from 100 to 500 g were taken from each carcass for potassium analysis. The mean value for mg of potassium per 100 g of muscle was 398. No significant effects of age upon muscle potassium levels were observed. Perinephric fat potassium content ranged from 0 to 20 mg per 100 g of fat. Mitteldorf and Landon

(1952) reported that the potassium content of raw beef rib eye ranged from 0.29 to 0.34 percent potassium. Seven composite samples, each representing one grade of beef (Choice, Good, Commercial, Utility, Canner, Cutter, and Bull) were used in the study. Swift and Berman (1959) measured the potassium content of eight muscles from two cows, a bull, and a heifer. Values ranged from 297 to 451 mg per 100 g of muscle, averaging 395. Van Dilla, Farmer, and Bohmen (1961) reported a range in the potassium content of pooled cattle muscle of 3.8 to 4.7 g per kg. Kulwich and coworkers (1961), in a study involving 16 beef rounds, reported a mean value of 0.375 for percent potassium in fat-free separable lean. Green, McNeill, and Robinson (1961) found the potassium concentration of the whole body of calves to be 0.21 percent while the potassium content of fat was found to vary from 0.01 to 0.03 percent. Clark _et al_. (1972) reported a range of 0.290 to 0.297 percent for the potassium levels of 99 beef carcasses when potassium was expressed on a fat-free basis.

Swine

Spray and Widdowson (1950) investigated the total potassium content in male pigs ranging in age from 0 to 259 days. At birth, the potassium level in the fat-free body tissue was 210 mg, while a value of 280 mg of potassium per 100 g of fat-free body tissue was found for the adult swine. Kirton, Gnaedinger, and Pearson (1963) reported that empty bodies (defined as intact animal minus the contents of the G. I. tract) of pigs contained 0.20 percent potassium, and the carcasses contained 0.21 percent. When expressed on a fat-free basis, the values increased to 0.30 and 0.34 percent, respectively. Green, McNeill, and Robinson (1961) found the concentration of potassium in 13 Yorkshires slaughtered at 200 pounds to be 0.24 percent, while Mullins _et al._ (1969) reported a value of 0.202 percent for the composite right sides of 32 Duroc pigs weighing approximately 90.0 kg.

K^{40} Estimates as Predictors of Lean in the Carcass and the Live Animal

Earlier in this review, citation was made to the work of Cheek and West (1955) in which they studied the relationship of lean body mass to the total potassium content of 30 rat carcasses. The researchers found a linear relationship between the two variables. Talso and coworkers (1960) reported the same linear trend from birth to adult life of some rats in a study where exchangeable potassium was used as a parameter of body composition.

Woodward and coworkers (1956) measured the potassium-40 emission of 13 human subjects in a 4-pi gamma ray detector and found that the potassium-40 emission was well correlated with the lean body mass as estimated by the tritium dilution method. Muldowney, Crooks, and Bluhm (1957), using potassium-42 as a tracer, found a highly significant correlation ($r = 0.90$) between total exchangeable potassium and lean body mass in a study of 30 humans ranging in age from 18 to 81 years.

Kirton et al. (1961), using ten lambs, obtained a correlation coefficient of 0.58 between separable lean and g of potassium per kg of live weight. Judge et al. (1963), Lohman et al. (1965) and Bridenstein et al. (1965a) have reported K^{40} count to account for 53 to 90.3 percent of the variation in lamb carcass lean muscle mass. Lohman and coworkers (1965) found that whole-body K^{40} count accounted for 90.3 percent of the variation in carcass lean in sheep, and the researchers concluded that K^{40} measurements on the live animal or the carcass were more precise in predicting carcass lean than either carcass weight or loin eye area. Breidenstein et al. (1965a) reported that K^{40} count accounted for 87.0 percent of the variation in lamb carcass lean mass. Judge and coworkers (1963), in a study involving 27 live lambs and 38 lamb carcasses, found a correlation of 0.73 between pounds of "edible portion" and K^{40} measurement. These researchers also reported a correlation of 0.91 between carcass weight and pounds of edible portion.

Research involving the evaluation of leanness in beef cattle using the K^{40} counting technique produced relatively consistant results. Kulwich and coworkers (1961) studied the relationship of gamma-ray emission measurements of 16 intact beef rounds to their physical and chemical composition. There was a highly significant negative correlation ($r = -0.87$) between potassium-40 emission and percent separable fat while a highly significant positive correlation (r = 0.80) was found between potassium-40 emission and percent separable lean. Lohman et al. (1964) observed that the fat-free lean tissue from 29 steers was significantly related to live weight and live potassium-40 count (r = 0.95 and 0.95). In a later report, Lohman et al. (1966) found that whole-body count was repeatable from day to day within 2 to 3 percent in 21 steers and predicted carcass lean with standard errors of estimate of less than 3 percent. Smith and coworkers (1965) found that live weight accounted for 86.7 percent of the total variation in fat-free lean in 46 steers ranging from 650 to 1200 pounds, while live body K^{40} count accounted for 42.5 percent of the total variation. Frahm, Walters, and McLellan (1971) studied 40 Angus bulls over four slaughter weight groups to evaluate the effectiveness of live K^{40} count and live weight separately and together. Live weight and K^{40} count following a 24-hour shrink accounted for 4 and 74 percent of the variation in fat-free lean, respectively. The standard error of estimate for predicting fat-free lean from K^{40} count was 8.4 pounds and no further reduction in the standard error was realized when live weight was also included in the prediction equation. McLellan (1970), in a study involving 31 steers and heifers, found that live weight accounted for 21 percent of the variation in pounds of fat-free lean, while the average of two K^{40} counts (after 24 hours shrink) was associated with 64 percent of the variation in fat-free lean.

Kulwich and coworkers (1958) studied potassium-40 gamma-ray measurements on four intact hams, followed with additional measurements after removing part of the separable fat, and then removing bone and additional separable fat. The values for measured K^{40} gamma rays per second per pound varied inversely with the percent of fat present, and a correlation of -0.966 was obtained. Breidenstein et al. (1965b) slaughtered 30 pigs after K^{40} counting. K^{40} count in a linear model with breed, sex, live weight, and carcass weight, accounted for 91.3 percent of the variation in carcass lean muscle mass. This same model without K^{40} count accounted for 44.7 percent of the variance. Mullins et al. (1968) reported a correlation coefficient of 0.70 between percent four lean cuts (ham, loin, picnic, and Boston Butt) and percent potassium in the carcass as measured by K^{40} based on a study involving 32 pigs. In another study involving 24 market hogs, Kirton, Gnaedinger, and Pearson (1963) reported a correlation of 0.77 between percent protein and percent potassium as determined by K^{40} count. Mullins et al. (1969) studied comparisons of potassium and other chemical constituents as indices of pork carcass composition. Significant positive correlations were observed between percent potassium of live pigs and percent ham, percent ham and loin, percent four lean cuts of 0.59, 0.54, and 0.60, respectively. Addison (1973) evaluated 115 market weight pigs with a K^{40} counter over a two-year period. Using a pooled prediction equation for fat-free lean, 77 percent of the variation was accounted for by live K^{40} count alone and 79 percent was accounted for when weight was added to the model.

Sources of Variation Associated With the Chemical Determination of Muscle Potassium

The technique used to estimate potassium concentration is of considerable importance when trying to accurately estimate the potassium content of tissue, whether it be muscle or fat. The difficulty of quantitating biological variation among animals within breed groups and treatments is that measurement errors are also contained within this "biological variation" quantity. Coefficients of variation in tissue potassium, a subject of considerable interest to some body composition workers, has seldom been separated into biological and technical components. Some researchers have studied the technical variation in the measurement of potassium and, consequently, have questioned the precision of instrumentation such as atomic absorption spectroscopy in estimating the potassium content of tissue.

Lohman, Dieter, and Norton (1970), using samples from 98 steers, examined the technical variation in the measurement of potassium in the lean muscle of steers. Seven cuts constituting the entire boneless, trimmed, right side from each of 98 steer carcasses were each sampled once. The samples were then analyzed in duplicate for ether-extractable components, nitrogen, and water within one year after the samples were collected and analyzed for potassium after three years. Potassium was extracted from the dry tissue and measured by atomic absorption spectroscopy (Perkin-Elmer model 303) using T.C.A. extraction procedure of Mounib and Evans (1957) as modified by Kirton and Pearson (1963). The solution used for the A.A.S. analysis was approximately 1 part sample to 1,000 parts dilutent. From eight potassium standards (1 through 8 ppm) used with each group of meat samples, a quadratic regression of potassium concentration on optical density was established to compute the potassium content of the meat samples. About 1,800 samples (including 400 reruns for duplicates that differed from each other by more than 5 percent) were analyzed by use of atomic absorption spectroscopy and averaged 60 samples per run in 33 runs over a year's time. A detailed statistical analysis was conducted on all components of the technical variation associated with the study. The error variance component, of which 67.6 percent was associated with the block effect, 0.4 percent with the cuts x blocks interaction, 19 percent with the steers x cuts x blocks interaction, and 13 percent with the mean of duplicates, totaled .00826 g^2, a standard deviation of 0.091 g and a coefficient of variation of 9.6 percent. Rerunning extracts from each of five cuts six times over a month resulted in failure to observe a stable relation among cuts in potassium concentration when measured by atomic absorption spectroscopy as indicated by significant interactions of cuts with runs. A coefficient of variation of 5.6 percent was obtained when using gamma-ray spectrometry to determine the potassium concentration of the same samples. These data suggest that there may be serious limitations in the procedure used to estimate potassium by atomic absorption spectroscopy.

Johnson, Walters, and Whiteman (1972) concluded that measurement variation was a large source of variation in determining the potassium content of muscle samples taken from the longissimus dorsi of 36 crossbred Angus-Hereford steers. The muscle tissue samples were thawed at room temperature and dried for twenty-four hours at 100° C. The dried samples were ashed in a muffle furnace for twelve hours at 575 to 600° C., and the ash dissolved in 1:3 HCl, transferred to a 25 ml volumetric flask and diluted to volume with 1:3 HCl. This preparation was then diluted 75 times by adding 0.1 ml to 7.4 mls of water, and potassium concentrations were read from this dilution. Muscle potassium was determined by atomic absorption spectroscopy using a Perkin-Elmer Model 303 spectrophotometer. The standard error for duplicate analysis was 0.322 g K/kg, while a coefficient of variation of the mean of duplicates was 11.1 percent. The coefficient of variation of 11.1 percent was in agreement with that of 9.6 percent reported by Lohman, Dieter, and Norton (1970).

Some researchers, using atomic absorption spectrometry, are reported to have estimated muscle potassium with minor technical variation. Bennink _et_ _al_. (1968) studied the potassium content of ground beef, wholesale cuts and internal organs from twelve steers. The chemical procedure conducted on the tissue samples first involved a 16-hour drying period under vacuum at 60° C. Fat was then extracted from the dried sample with pentane in a Bailey-Walker apparatus. Potassium was determined on the residue, which was composed of the fat-free dry solids. For potassium analysis, the fat-free dry solids were finely ground through a 24 mesh/cm^2 screen in a Wiley mill. One to two g of the ground material were weighted quantitatively into polyethylene bottles and 200 ml of two percent trichloracetic acid added. After a minimum of 24 hours of extraction, the solution was filtered through Whatman No. 40 filter paper. Duplicate dilutions for analysis by atomic absorption spectroscopy were prepared from the filtrate by adding 1 ml of filtrate to 19 ml of 2 percent trichloracetic acid. The coefficient of variation for the determination of potassium by this method was 1.96 percent on 14 replicates from the same meat sample, which had a mean of 14.3 g K/kg fat-free dry solids. The means were similar but the standard deviations and ranges were greater when potassium was estimated by K^{40} counting procedures than when estimated by atomic absorption spectroscopy. The coefficient of variation for estimating potassium by gamma-ray spectrometry was 4.0 percent, compared to 1.96 percent for the coefficient of variation using the atomic absorption spectrometer.

Kirton and Pearson (1963) used a TCA extraction method for determining the potassium concentration in the lean from ten lambs. The potassium determinations were made with a Beckman D.U. spectrophotometer equipped with a flame attachment with an oxygen-hydrogen burner. The standard error of the duplicate means was calculated from the error mean square and found to range from 15 to 25 ppm of potassium, which suggested reasonable agreement between duplicate samples. The coefficient of variation for potassium concentrations of the separable lean of ten lamb carcasses was 4.46 percent when expressed on a wet-tissue basis and 5.5 percent when expressed on a fat-free basis. These workers emphasized that the previously mentioned values did not take into account day to day variations in the operation of the flame photometer as duplicate analyses were always carried out on the same day. The coefficient of variation for potassium in the same separable lean as determined by the K^{40} method was 6.7 percent.

Gillett, Pearson, and Kirton (1965) determined the potassium content of various pig muscles. The potassium content of each muscle was determined by flame photometry utilizing the TCA extraction procedure of Mounib and Evans (1957) as modified by Kirton and Pearson (1963). A Beckman D.U. spectrophotometer with a model 9220 flame attachment was used for the analysis. Samples weighing 2 to 3 g were run in duplicate. Generally, all duplicate values for all six muscles of each pig were within 100 ppm. When potassium content was expressed on a wet-tissue basis, coefficients of variation for specific muscles ranged from 4.97 to 2.71 percent; when expressed on a fat-free, moisture-free basis, the coefficients of variation for specific muscles ranged from 6.27 to 3.79 percent.

Potassium Extraction Methods

A few researchers have studied and compared different methods of extracting potassium from different tissues. One of the earliest studies was conducted by Mounib and Evans (1957) who studied three different methods of extracting potassium from various sheep tissues. The three methods studied were digestion with trichloracetic acid (Method A), boiling under reflux (Method B), and boiling under reflux plus acidification (Method C). The three extraction methods were conducted on heart, liver, kidney, and muscle tissue of sheep. Methods A and C extracted significantly greater amounts of potassium from all four tissues than did Method B. These workers concluded that acidification was a very important step in releasing potassium from certain tissues. Although acidification did not appear to be necessary for complete liberation of potassium from skeletal muscle, it did appear necessary in the case of the heart, liver, and kidney. It was concluded that potassium may be found in more than one form in a tissue and that the state in which potassium is present may be different in the tissue from one organ to another.

Kirton and Pearson (1963) compared four methods for potassium extraction of pork and lamb tissue. Oven ashing, perchloric acid ashing, extraction by boiling and acidification with nitric acid, and extraction by homogenization in 2 percent thrichloracetic acid (TCA). According to this report, the TCA extraction method for potassium was found to be repeatable and relatively simple to accomplish when compared to the other three methods. Furthermore, the recovery of known amounts of potassium indicated that the method was accurate. The workers did not report any statistical comparisons between the four methods; however, they did describe in detail the trichloracetic acid extraction procedure.

While it may appear that much of the variation in chemically determined potassium may be due to differences in extraction procedures, Lohman, Dieter, and Norton (1970) and Kirton and Pearson (1963), all using the same extraction procedure, reported large precision differences in measuring the potassium concentration in lean tissue.

Conditions Associated with the Animal Which Influence K^{40} Detection Efficiency

The use of whole body potassium as a quantitative index of the fat-free body assumes that potassium is maintained in a relatively constant concentration within the lean muscle mass. Some disagreement has appeared in the literature concerning the constancy of the potassium content in mammalian muscles. In fact, several researchers have concluded that differences in the potassium concentration of different muscles may be an important source of error in the K^{40} technique for estimating composition. Because different muscle structures are associated with different muscle functions, differences in composition between muscles appear likely.

Holliday _et_ _al_. (1957) reported significant differences between potassium content per unit fat-free solids of the thigh and back muscles in 11 to 12 week-old rats and in 17 to 19 week-old rats. They found that differences in connective tissue was the primary cause for potassium concentration differences.

Flear, Carpenter, and Florence (1965) reported that nearly as much variation was found in the potassium in different muscles of the same subject as in the same muscle of different subjects in a study involving 34 humans.

Muscle to muscle variability in potassium concentration in sheep was reported by Gillett and coworkers (1968). The portion of the longissimus dorsi muscle between the twelfth thoracic and fifth lumbar vertebra was utilized in the potassium analysis, as well as the semimembranosus, semitendinosus, and rectus femoris muscles in their entirety. The potassium concentrations were determined on a trichloracetic acid extract of the samples by a flame photometric procedure. All the muscles studied individually differed significantly ($P \leq .05$) in potassium content when expressed on a wet basis (g K per kg muscle). The percent decrease between the highest and lowest muscles was 8 percent and this difference increased to a 12.77 percent difference when potassium concentration was expressed on a fat-free, moisture-free basis. The potassium content of the various muscles ranged from 0.31 to 0.45 percent with the order of decreasing potassium content being as follows: semitendinosus, rectus femoris, semimembranosus, and the longissimus dorsi muscle.

Lawrie and Pomeroy (1963) reported significant differences in potassium content between muscles with different structure and function. They studied the potassium content of five muscles (longissimus dorsi, psoas major, rectus femoris, triceps, and extensor carpi radialis) from pigs slaughtered at 150, 200, and 250 pounds. Potassium concentrations of the psoas major and rectus femoris were significantly higher ($P \leq .01$) than those of longissimus dorsi, triceps, and extensor carpi radialis (0.37 percent vs. 0.31 percent). These workers concluded that differences between muscles in the ratio of potassium to fat-free, dry matter may reflect differences in connective tissue content. On the other hand, Pfau and coworkers (1963) were not able to demonstrate significant differences between two anatomically different muscles from 60 pigs when potassium was expressed on a fat-free, moisture-free basis, or on a protein basis. The muscles studied were the semimembranosus and the longissimus dorsi. Briskey <u>et</u> <u>al</u>. (1959a) studied the potassium content of pork ham muscles which ranged from watery and pale to dry and dark in appearance. These researchers reported that there were no consistent differences in potassium concentrations when expressed on a fat-free dry weight basis. Briskey et al. (1959b) reported that the difference in potassium concentration (on a fat-free dry tissue basis) in pork muscle from 16 gilts associated with different levels of forced exercise prior to slaughter were not significant. Mullins et al. (1969) studied the potassium concentration in 32 Duroc pigs weighing approximately 90.0 kg. They found that on a fat-free, moisture-free basis, the soft tissue of the ham, loin, and shoulder contained practically the same percent potassium, 1.759, 1.739, and 1.751, respectively. No significant differences in potassium among wholesale cuts were evident. Gillett, Pearson, and Kirton (1965) slaughtered six Hampshire and six Yorkshire barrows between 186 and 220 pounds, and excised six muscles from each carcass. The muscles studied were the longissimus dorsi, semimembranosus, semitendinosus, psoas major, biceps femoris, and rectus femoris. When the muscles were compared on a wet basis (g K/kg of muscle) the rectus femoris contained the most potassium and the psoas major the lowest with a difference of 11.9 percent between the mean values of these two muscles. When the potassium content was expressed on a fat-free, moisture-free basis (g K/kg moisture-free muscle) the percent difference between means of the rectus femoris (highest) and psoas major (lowest) amounted to 10.5 percent.

The potassium content differences for ground beef from one side of each of 12 steers (fraternal or identical twins) and for eight wholesale cuts of three dairy cows were made by Bennink _et al_. (1968). These researchers found no significant differences in potassium content among wholesale cuts within cows or among cows, or among ground beef samples for different steers. Lohman, Ball, and Norton (1970) studied the variability of muscle potassium concentration of different beef cuts of 98 steers. The steers were Holstein, Angus-Holstein, Charolais-Angus, or Angus and were fed a diet either high or low in roughage. Half of the steers were implanted with diethylstilbestrol and the steers were slaughtered in one of four pre-determined weight groups (306, 385, 465, and 544 kg). The lowest average potassium concentration (fat-free, dry matter basis) was in the rib, 13.72 g per kg; while the highest was in the round, 15.27 g per kg. There was no consistent trend in potassium deviations from one breed to another or from one weight group to another, nor for hormone treatment or energy intake level. Ward, Johnson, and Tyler (1967) studied the relationship of potassium measured as K^{40} to the moisture and fat content of ground beef. Using only five animals and eight wholesale cuts as experimental subjects, they found a significant difference between cows in potassium concentration on a fat-free basis but not between wholesale cuts within cows.

Gillett _et_ _al_. (1967) reported a difference in amount of potassium per unit of muscle weight in seven muscles of beef cattle. Carcasses from seven Angus, seven Hereford, and two Shorthorn steers with weights ranging between 232.2 and 344.3 kg were used in this study. The researchers found that the rectus femoris and semitendinosus muscles contained significantly ($P \leq .05$) greater amounts of potassium (expressed on a fat-free, moisture-free basis) than did the psoas major and longissimus dorsi muscles. The researchers concluded that variation in the content of different muscles may be an important source of error in the K^{40} method for estimating composition. Duggleby and Seebeck (1967) measured 152 samples of muscle, fat, and bone from seven steers for potassium concentration. Potassium estimates were made with a sodium iodide crystal. Highly significant differences were reported between muscle groups and between animals. Clark _et_ _al_. (1972) conducted chemical potassium analyses on wholesale cuts from the carcasses of 99 steers slaughtered at 227, 341, and 454 kg. When comparisons were made among carcass weight groups for potassium content of the wholesale cuts, there were significant differences on the wet tissue basis. When the wholesale cuts were evaluated within a weight group, there were significant differences in potassium expressed on a wet, fat-free, and fat-free, moisture-free basis. Generally, the potassium concentrations in the round were significantly ($P \leq .05$) greater when compared to the potassium concentrations of the other wholesale cuts.

Sample mass is another factor that may influence K^{40} detection efficiency. According to Anderson (1959), sample mass has two important effects on the count of a given sample. First, the sample mass lowers the total count by absorbing a fraction of the background radiation, which in the absence of a sample, would pass into a detector and be counted. This physical phenomenon is called background depression and results in lowering the background radiation reaching the detectors below that which actually exists in the atmosphere. Twardock and coworkers (1966) reported this same phenomenon and described their efforts to determine background depression of large-volume samples by introducing distilled water in box phantoms and measuring background count rates. Five box phantoms were constructed to contain known quantities of KCl in water; phantom weights were 200 kg, 296 kg, 392 kg, 448 kg, and 585 kg. Box dimensions were selected to approximate the length, girth, and width of a steer of the same weight. By measuring the count rate, the K^{40} detection efficiency for each phantom weight was determined from its known K^{40} gamma-emission rate. The researchers found that a more meaningful efficiency calibration was obtained by means of K^{42} injections rather than using the box phantoms since it was impossible to reproduce the geometry, self-absorption, and K^{40} distribution of the animal being measured.

Another effect of sample mass on counting efficiency as reported by Anderson (1959) involved the self-absorption of radiation by the sample. Self-absorption can be defined as the absorption of gamma radiation by the sample from which the rays originated. Anderson found that the greater the sample mass, the lower the counting efficiency. Twardock *et al*. (1966) reported the same trend, and found that the count rate from a given quantity of radioactive substance varies inversely with the mass of the animal or standard in which the material is dispersed.

Several researchers have found that sample-to-detector geometry also influences the detection efficiency of a K^{40} counter. Twardock *et al*. (1966) found, in studying the Illinois liquid scintillation counter, that a smaller sample was more effectively surrounded by the detector than a larger sample. They used two different detector positions in counting cattle and found that the close-fitting detector was 20 percent more efficient than the loose-fitting detector. However, because of the relatively high count rates of cattle, precise measurements were also readily attained at the lower detecting efficiency. Lohman and coworkers (1966) reported that the positioning of steers with respect to the scintillation detector was a source of error affecting the precision of estimated whole-body potassium. Moser (1970), in a study involving the K^{40} counting of hogs weighing 100, 150, 200, 250, and 300 pounds, observed lower correlations between K^{40} counts and measures of leanness in hogs of lighter weights when compared to those of heavier weights. He concluded that positioning of the animals in the K^{40}

counter and the ratio of sample to detector volume may have had a detrimental effect on the correlations of the lighter weight pigs. The smaller pigs occupied only a small portion of the area inside the counting chamber, therefore, allowing a lesser chance for the gamma radiation emitted from the animals to reach the detectors.

CHAPTER III

MATERIALS AND METHODS

General

One hundred market barrows (70 Hampshires and 30 Yorkshires) composed of ten replicates were evaluated by the Oklahoma K^{40} whole-body counter (using plastic scintillation detectors) beginning in March, 1972, and ending in October, 1973. The barrows were obtained from University herds weighing between 60 and 70 pounds each and were generally large framed, growthy, heavily muscled pigs. The replicates, each consisting of ten feeder pigs, were assigned to slaughter weight groups of 100, 150, 200, 250, and 300 pounds. From each replication, two pigs were randomly allotted to each slaughter weight group, making a total of 20 pigs in each of the five slaughter groups as shown in Table I. The study was divided into three trials, the first consisting of two replications, while trials two and three were composed of four replications each.

The design for live evaluation of the pigs by K^{40} counting is presented in Table II. Each pig was taken off feed and K^{40} evaluated at each weight and placed back on feed until it reached the predetermined slaughter weight as described in Table II. Ten replications of ten pigs each

TABLE I

EXPERIMENTAL DESIGN

	Slaughter Weight Groups (pounds)				
Replication	100	150	200	250	300
I	2[a]	2	2	2	2
--	--	--	--	--	--
X	2	2	2	2	2
Total	20[b]	20	20	20	20

[a] Number of animals per replication per weight group.

[b] Total number of animals per weight group.

TABLE II

DESIGN FOR LIVE K^{40} EVALUATION

	Slaughter Weight Groups (pounds)				
Replication	100	150	200	250	300
I	10[a]	8	6	4	2
--	--	--	--	--	--
X	10	8	6	4	2
Total	100[b]	80	60	40	20

[a] Number of animals K^{40} evaluated per weight group per replication.

[b] Total number of animals K^{40} evaluated per weight group.

provided a total of 100 pigs K^{40} evaluated at 100 pounds, 80 at 150 pounds, 60 at 200 pounds, 40 at 250 pounds, and 20 at 300 pounds. This design was used in an effort to evaluate the K^{40} counter as a monitor of body composition changes in growing and fattening swine and to establish the repeatability of the K^{40} counter at five different slaughter weights.

All pigs were self-fed a corn-soybean ration containing 16 percent protein, the ingredients of which are presented in Table III.

TABLE III

SIXTEEN PERCENT CORN-SOYBEAN MEAL RATION

Ingredients	Percent in Ration	Pounds
Corn (8.8%)	73.61	1,472.20
Soybean meal (44%)	22.89	457.80
Calcium carbonate	1.20	24.00
Dicalcium phosphate	1.30	26.00
Vitamin-TM mix 5450	0.50	10.00
Salt (plain)	0.50	10.00
Total	100.00	2,000.00

O.S.U. K^{40} Whole-Body Counter

The whole-body counter described by Moser (1970), Frahm *et al.* (1971), and McLellan (1970) was also used in this study; however, some modifications were made in an effort to increase the counting efficiency of hogs over a range of live weights (100 to 300 pounds). Van Dilla and Anderson (1962) suggested that radiation decay products of radium (Ra^{226}) and thorium (Th^{232}) arising from the earth's crust were partially responsible for high background count. These two natural radioactive elements possess energy spectra that overlap the energy spectra of K^{40}; consequently, a portion of the background radiation may come from Ra^{226} and Th^{232} in addition to the environmental sources of K^{40} itself. In an effort to reduce as much of the thorium and radium radiation as possible, twenty-four inches of water were placed under the counter.

Several workers including Twardock _et al_. (1966) and Lohman _et al_. (1966) have found that sample-to-detector geometry also influences the detection efficiency of a K^{40} counter. In most K^{40} counters, a smaller sample is more effectively surrounded by the detector than is a larger sample and, consequently, a larger proportion of the gamma rays leaving the sample will interact with the detectors. Moser (1970) found the positioning of animals in the counting chamber and the ratio of sample to detector volume to be important sources of variation in the K^{40} evaluating of swine at different weights. The chance of losing emitted gamma rays from samples is reduced when an animal is positioned as close to the detectors as possible.

The Oklahoma counter was initially designed to K^{40} evaluate animals weighing approximately 454.5 kg; however, it was constructed in such a manner that the detectors could be moved in order to more closely fit the shape of the animal or sample being counted. In this study, only six of the original fourteen K^{40} scintillation detectors were used and the circular detector at the rear of the chamber was not utilized. This new detector arrangement, illustrated in Figure 1, increased the ratio of sample to detector volume considerably. In addition to a new detector arrangement, a method of positioning the barrows as close to the detector system as possible was devised. Those pigs in the light weight groups were elevated in the counting chamber by placing one or more one-inch wooden planks on the floor of the chamber in order to maintain the same distance between animals of different weights and the detectors.

Duncan Lean-Meter Probe

The Duncan Lean-Meter provides a rapid method for distinguishing between muscular and fatty tissues in various species of meat animals. The method is based on the differences in electrical conductivity of fat and muscle; fat being a relatively poor conductor, while muscle and blood are good conductors. The electrical conductivity of tissue is measured at the tip of the probe. The Lean-Meter has an ampmeter which reads either fat or lean, depending upon the kind of tissue contacted by the tip of the probe. As an operator probes an animal, he can immediately

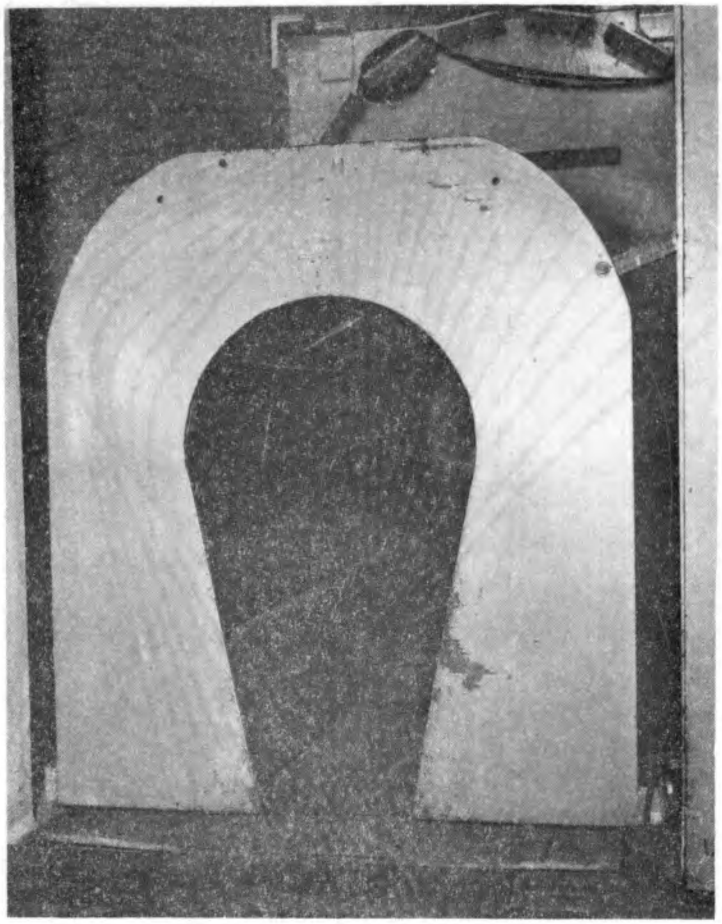

Figure 1. New Detector Arrangement Used in the K^{40} Counting of Swine.

determine when the probe has passed through the subcutaneous fat and entered the lean by observing the ampmeter (indicator).

K^{40} and Live Probe Evaluation Procedures

As the pigs reached the shrunk live weights of 100, 150, 200, 250, and 300 pounds, they were taken off feed for 24 hours and thoroughly washed to remove any foreign materials that might influence the K^{40} count. Each pig was K^{40} evaluated twice on the same day enabling a repeatability measurement to be conducted on the K^{40} counter.

The "Net K^{40} Count Per Minute" for each animal was obtained by (1) taking five one-minute "foreground" counts with the chamber empty, (2) taking five one-minute sample counts with an experimental animal in the chamber, and (3) finally taking a set of five one-minute "background" counts with the chamber empty. The average of the foreground and background measurements were subtracted from the average sample count to obtain net K^{40} count for each animal, and the net count was then converted to counts per minute by dividing net counts for the animal by five.

A KCl standard potassium source (619.03 g KCl) was counted prior to the K^{40} evaluation of the first animal and immediately after the counting of the last animal in an effort to monitor and determine counter efficiency for that day. The same counting procedure previously described for the K^{40} evaluation of the hogs was followed in counting the potassium standard. Since the K^{40} evaluation of the hogs in this project extended over a period of 19 months and under somewhat different climatic conditions, all net K^{40} counts were adjusted to a standard 21 percent counting efficiency. The formula for calculating counter efficiency (percent) for a single day was the following:

$$\frac{\text{Average Net KCl Count}}{66{,}300} \times 100 = \text{counter efficiency (\%)}$$

The value "66,300" is the actual number of K^{40} disintegrations emitted per minute from the standard potassium source (KCl). The formula used to adjust all pig K^{40} counts to a standard 21 percent efficiency was the following:

$$\frac{\text{Net Count x 21\%}}{\text{\% Counting Efficiency for a Particular Day}} = \begin{array}{l}\text{adjusted}\\ \text{net count}\end{array}$$

After the pigs reached their predetermined slaughter weight, they were probed with a Duncan Lean-Meter prior to the final K^{40} live evaluation. The animals were probed at a position approximately 1½ inches off the midline of the back at the first rib, last rib, and last lumbar vertebra on the right side; however, if a reading appeared to be in question, a second reading was taken on the left side of the midline. A mean probe estimate was determined by averaging the three measurements made on each animal.

Slaughter, Separation, and Sampling Procedures

After the pigs reached their predetermined weight and were K^{40} evaluated for the final time, they were transported to the University Meat Laboratory and slaughtered the following day. During the slaughtering process, the leaf fat and kidneys were removed. The hot carcasses were weighed and placed in a holding cooler (34-36^{o} F.) for at least 24 hours. Carcass measurements obtained before physically separating the right side were chilled carcass weight, carcass length, and average backfat thickness.

Carcass Separation

The right side of each carcass was divided into wholesale cuts in the following manner: the shoulder was removed perpendicular to the axis of the carcass between the second and third ribs. The ham was removed perpendicular to the axis of the hind leg at the third sacral vertebra. The loin was removed from the belly along a line ventral to the tenderloin muscle at the posterior end of the loin and immediately below the body of the third thoracic vertebra at the anterior end. Weights were recorded for the rough wholesale cuts including the ham, loin, shoulder, and "thin cuts." "Thin cuts" were composed of the jowl, belly, and the fore and hind shanks. The wholesale cuts were weighed and physically separated into fat, very closely trimmed lean, and bone. During the physical separation process, a special effort was made to remove as much intermuscular fat as possible from the lean in order to obtain the most accurate measure of closely trimmed lean.

The biceps femoris and the semimembranosus muscles were excised from the ham of each right side as well as a portion of the longissimus dorsi extending from the third to the tenth ribs. The two ham muscles were individually weighed for purposes of observing possible trends in muscle development as related to age and weight.

After the lean, fat, and bone weights were recorded, the chilled closely trimmed lean mass was thoroughly mixed together in preparation for grinding and sampling for ether-extract and potassium analyses. The quantity "fat-free lean" used as the end-point for carcass lean measurement was computed by subtracting the pounds of ether-extractable portion from the total pounds of closely trimmed separable lean.

Sampling

The closely trimmed separable lean was sampled using a procedure similar to that described by Munson et al. (1966). All sampling equipment, including the grinder and mixer, was placed in a cooler ($34-36^{\circ}$ F.) at least 12 hours prior to sampling in order to obtain a uniform temperature between the lean mass and the equipment. A more thorough job of sampling was observed when a constant temperature was maintained between equipment and separable lean because fat would continue to mix with the lean rather than collect on blades, plates, and other parts of the equipment. The separable lean was first mixed by hand in order to obtain a uniform mixture of fat and lean pieces. After the hand mixing, the lean was ground through a coarse plate (3/8 inch) and mechanically mixed in a "Leland" stainless steel, meat mixing machine for approximately two minutes. The lean mass was then ground through a fine plate (1/8 inch), mechanically mixed, and finally reground through the same plate.

Fifteen "grab samples" were taken at uniform intervals during the final grinding period in an effort to obtain samples as representative as possible of the entire carcass. Three sub-samples, each composed of five randomly allotted grab samples, were labeled A, B, and C and individually hand mixed. After mixing, 50 g of the lean from each sub-sample (A, B, and C) were placed in properly labeled plastic Whirl-Pac bags. The top portion of the bags was compressed before sealing to remove as much air as possible. Finally, the samples were stored in a freezer (-17.80° C.) until removed for chemical analyses.

Chemical Analyses

Moisture Determination

Moisture determinations on ground samples of "separable lean," biceps femoris, longissimus dorsi, and semimembranosus muscles were conducted as outlined by A.O.A.C. (1965). A Thelco Model 29 drying oven with a vacuum attachment was used to dry all samples.

Ether Extraction Procedure

Prior to extraction, the samples were thawed in a 1.7° C. atmosphere and then homogenized at 20° C. using a Sorvall

Omni-Mixer. Two aliquots, each weighing approximately 5.0 g, were taken from each sub-sample (A, B, and C) and percent "ether-extract" was determined using the Soxhlet Method (A.O.A.C., 1965). The average of six determinations of the fat content became the estimate of percent ether-extract in the very closely trimmed separable lean of a carcass. Fat-free lean was determined by subtracting total ether-extractable materials from the weight of the boneless, closely trimmed muscle mass from the right carcass half.

Chemical Potassium Procedure

Muscle potassium analyses were conducted on representative samples from the first six replications of pigs slaughtered with the amount of potassium expressed on a fat-free, dry matter basis. The potassium analysis involved a wet ashing procedure using two one-g aliquots from representative samples of the ground separable lean of the right carcass halves and the three specified muscles. Samples were removed from the freezer, thawed in a 1.7° C. atmosphere, thoroughly mixed and duplicate aliquots (approximately one g) were placed into 50 ml beakers. Twenty-five ml of an acid digestion solution consisting of three parts Perchloric acid (70 percent) to one part of Nitric acid was added to each beaker. The beakers were then placed on an electrical hot plate which was situated in a stainless steel hood. Digestion of the samples was conducted at 85° C. and generally took from 18 to 30 hours, depending on the fat content of the samples. After digestion was completed, the samples were removed from the hot plate and allowed to cool to room temperature. Each beaker was then thoroughly rinsed with deionized glass distilled water and the contents filtered through a long stem funnel into a 500 ml volumetric flask. After thorough rinsing of the beaker, the volume in the flask was increased to 500 ml with distilled water. Twenty ml aliquots were taken from each 500 ml flask, placed in vials, and identified. The vials were then taken to the O.S.U. Soils Testing Laboratory for potassium analysis on a Perkin-Elmer 403 Atomic Absorption Spectrophotometer. Blank samples of digested acid and distilled water were also read to correct for exogenous potassium. Potassium readings obtained from the spectrophotometer were expressed as ppm; and the ppm were converted to g of potassium by the formula: ppm x 5 = g (x 10^{-2}) potassium. The concentration of potassium was then expressed on a fat-free, dry matter basis.

Statistical Analyses

Means and standard deviations were determined according to methods outlined by Steel and Torrie (1960). Correlation coefficients, simple regression studies, and orthogonal comparisons among weight group totals were completed at the Oklahoma State University Computer Center using The Statistical Analysis System, developed by Barr and Goodnight and described by A User's Guide to the Statistical Analysis System by Service (1972).

The data from the chemical analyses were examined using a heirarchal (nested) design. Analysis of variance for ether-extract and potassium determinations of both breeds are presented in Tables XLIII, XLIV, XLV, and XLVI of the Appendix. The error mean square for each chemical determination was obtained by pooling the error mean squares of both breeds; consequently, the same error mean square appears for both Hampshires and Yorkshires when observing the Analysis of Variance Tables concerning ether-extraction and the potassium determination.

Mean muscle differences (biceps femoris, longissimus dorsi, and semimembranosus muscles) at each weight (100, 150, 200, 250, and 300 pounds) for percent ether-extract and mg of potassium per g of ground separable lean were determined by using the LSD method as described by Steel and Torrie (1960).

CHAPTER IV

RESULTS AND DISCUSSION

The results are discussed in three parts: (1) the association of slaughter weight with certain live estimates, carcass measurements and carcass composition; (2) the association of live and carcass measurements with carcass leanness for pigs slaughtered at five different weights; and (3) the chemical composition of separable lean and of specific muscles from pigs slaughtered at five different weights.

The study involved 30 Yorkshire and 70 Hampshire pigs, the majority of which were large framed, heavily muscled pigs and, therefore, were not considered to be representative of the average pig found in the swine industry at the present time. Their superior meatiness will become quite evident and must be kept in mind when interpreting the results of this study. In an effort to simplify the analysis of the data, the results were analyzed on a breed basis.

The Association of Slaughter Weight with Certain Live Estimates, Carcass Measurements, and Carcass Composition

The means and standard deviations for live weight gains, pounds of lean per day of age and pounds of fat-free lean per day of age at five different weights are presented in Tables IV and V for Yorkshires and Hampshires, respectively. Average daily gain on test was calculated for the intervals between the initial weight and the predetermined slaughter weights. Average daily gain was greatest at lighter weights and decreased in both breeds as the pigs reached the heavier weight groups. Zobrisky *et al.* (1958) in a study using 72 Landrace-Poland crosses reported slightly higher rates of gain at 100, 150, 200, 250, and 300 pounds but indicated that the rate of average daily gain decreased after the pigs reached 200 pounds live weight. The rate of gain of the pigs in this study was probably influenced by excessive handling due to weekly weighing and also a 24-hour shrink period prior to K^{40} counting as pigs reached each 50 pound weight interval. As was expected, the greatest increases in both pounds of lean cuts and pounds of fat-free lean per day of age for both breeds occurred between 100 and 150 pounds, while the smallest increase in all cases was found to be between 250 and 300 pounds. It appears from these data that the Yorkshires, generally, had a higher average daily gain, a greater live weight per day of age, were younger in reaching each of the five different slaughter and count weights, and yielded more pounds of lean cuts per day of age than did the Hampshire pigs.

TABLE IV

MEANS AND STANDARD DEVIATIONS FOR LIVE WEIGHT GAINS FOR YORKSHIRES SLAUGHTERED AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Number of animals	6	6	6	6	6
Average daily gain on test, lbs.[a]	1.42 ± 0.20	1.88 ± 0.29	1.88 ± 0.35	1.61 ± 0.42	1.49 ± 0.34
Live weight per day of age, lbs.	0.90 ± 0.097	1.07 ± 0.115	1.15 ± 0.101	1.21 ± 0.131	1.27 ± 0.117
Age in days[b]	115.6 ±13.40	142.7 ±13.3	171.3 ±16.8	206.2 ±19.2	283.3 ±25.1
Lean cuts per day of age, lbs.	0.368± 0.025	0.411± 0.029	0.484± 0.033	0.535± 0.039	0.535± 0.040
Fat-free lean per day of age, lbs.	0.329± 0.026	0.368± 0.028	0.424± 0.030	0.466± 0.036	0.465± 0.034

[a] Rate of gain between initial weight and 100 lbs. was 1.42±0.20; rate of gain between 100 and 150 lbs. was 1.88±0.29, etc.

[b] Age in days refers to the average age of all the pigs remaining at the average slaughter weight of each weight group; i.e., age at 100 lbs. refers to the average age of 30 pigs; age at 150 lbs. refers to the average age of 24 pigs, etc.

TABLE V

MEANS AND STANDARD DEVIATIONS FOR LIVE WEIGHT GAINS FOR HAMPSHIRES SLAUGHTERED AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Number of animals	14	14	14	14	14
Average daily gain on test, lbs.[a]	1.38 ± 0.18	1.76 ± 0.22	1.69 ± 0.31	1.60 ± 0.32	1.41 ± 0.21
Live weight per day of age, lbs.	0.84 ± 0.086	1.02 ± 0.087	1.12 ± 0.082	1.18 ± 0.079	1.20 ± 0.089
Age in days[b]	121.9 ±12.3	149.4 ±12.9	178.8 ±13.8	212.2 ±15.3	250.7 ±17.5
Lean cuts per day of age, lbs.	0.364± 0.021	0.442± 0.028	0.461± 0.031	0.501± 0.040	0.476± 0.039
Fat-free lean per day of age, lbs.	0.322± 0.024	0.381± 0.007	0.393± 0.008	0.420± 0.010	0.401± 0.008

[a] Rate of gain between initial weight and 100 lbs. was 1.42±0.20; rate of gain between 100 and 150 lbs. was 1.88±0.29, etc.

[b] Age in days refers to the average age of all the pigs remaining at the average slaughter weight of each weight group; i.e., age at 100 lbs. refers to the average age of 30 pigs; age at 150 lbs. refers to the average age of 24 pigs, etc.

Live Estimates

One of the primary objectives of this study was to observe any trends in the association between live measurements obtained from two different techniques (K^{40} whole-body counting and live backfat probe) and various carcass measurements at five different slaughter weights. However, before establishing any associations between live evaluation instruments and carcass measurements, one must determine the repeatability of those instruments in question. When referring to K^{40} whole-body counting, "repeatability" refers to the measure of the association of two independent counts taken on the same animal on the same day. In an effort to determine the "repeatability" of the O.S.U. whole-body counter, every pig was counted two times on the same day. In a majority of the cases, the pigs were K^{40} counted once in the morning and once in the afternoon. Correlation coefficients were calculated to evaluate and express the association between two K^{40} counts taken at different times on the same animal and are presented in Table VI.

The correlation coefficients between the two counts, each count being the average of ten one-minute counts, ranged from 0.800 to 0.945 and all values were significant ($P \leq .01$). The positive correlation coefficients indicated that there was good agreement between the two readings and that the K^{40} whole-body counter was repeating itself reasonably well. Repeatabilities tended to increase as slaughter weight increased up to a correlation of 0.945 for

TABLE VI

CORRELATION COEFFICIENTS BETWEEN FIRST AND SECOND LIVE K^{40} COUNTS PER MINUTE

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Number of animals	100	80	60	40	20
Correlation Coefficients	0.800^{**}	0.916^{**}	0.923^{**}	0.945^{**}	0.920^{**}

** P .01

the 250-pound weight group, with the lowest correlation being 0.800 for the 100-pound weight group. This same trend was observed by Moser (1970) who reported a correlation coefficient of 0.72 and 0.94 for 100 and 300 pound weight groups, respectively.

Anderson (1959) reported a linear relationship between sample mass and background depression and demonstrated that in humans, background radiation was depressed at the rate of about 10 percent of the net whole-body count from humans weighing between 79.5 to 113.6 kg. It is therefore reasoned that as pigs increase in weight and mass, a greater portion of the background radiation is absorbed, rather than interacting with the detectors and being counted. Because of the insulating effect of the mass, variation in count rate caused by randomness of radioactive disintegration is partially masked. Sudden bursts of atmospheric disintegrations would have less effect on the total count of heavier, larger pigs than in lighter pigs having less body mass.

One of the objectives of this experiment was to study the relationships between certain traits and slaughter weight. As previously mentioned, the population of 100 pigs was divided into five weight groups; consequently, 20 pigs were slaughtered at 100, 150, 200, 250, and 300 pounds. An analysis of variance was conducted for each trait considered in this study and in most cases, slaughter weight accounted for a significant portion of the variation associated with the traits in question. Slaughter weight significance is indicated in Table VII and Appendix Tables XXXV-XL in the column entitled "Slaughter Weight Mean Square (M.S.)." Orthogonal comparisons were used to characterize the variation of certain traits by separating the total sums of squares of the traits into linear, quadratic, cubic, and quartic components associated with five different weight groups. Only significant linear and quadratic responses will be discussed since cubic and quartic effects would not be expected in the traits considered. In fact, the cubic and quartic sums of squares were added together and presented in Table VII and Appendix Tables XXXV-XL as "Other Sums of Squares (S.S.)."

The linear test does not prove linearity of response but suggests whether or not a significant portion of the sums of squares associated with weight is explainable by a non-horizontal, straight line plotted across the weight groups studied. When the sums of squares associated with a linear test accounts for the majority of the total sums of squares associated with weight groups, the data rather strongly suggests that the principle relationship between the trait in question and weight is linearlike. The quadratic test, if significant, suggests that there is a non-linear relationship in at least some portion of the weight range studied.

The means and standard errors for certain live measures taken at different weights are presented in Tables VIII and IX for Yorkshires and Hampshires, respectively. The mean

TABLE VII

MEAN SQUARES FOR K^{40} CPM AND BACKFAT PROBE SHOWING RELATIONSHIP TO SLAUGHTER WEIGHT GROUPS

Measurements	Slaughter Weight S.S.	Slaughter Weight M.S.	Linear S.S.	Quadratic S.S.	Other S.S.	E.M.S.
Yorkshires						
K^{40} CPM, live	31,392,594	7,848,149**	30,929,780**	396,561	66,253	214,941
Duncan Meter backfat probe, in.	2.267	0.567**	2.171**	0.092*	0.005	0.016
Hampshires						
K^{40} CPM, live	53,801,566	13,450,392**	50,245,723**	2,758,458**	797,383	178,134
Duncan Meter backfat probe, in.	5.989	1.497**	5.920**	0.057*	0.012	0.012

* $P \leq .05$

** $P \leq .01$

TABLE VIII

MEANS AND STANDARD ERRORS FOR LIVE MEASUREMENTS ON YORKSHIRES SLAUGHTERED AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Number of animals	6	6	6	6	6
Slaughter wt., lbs.[a]	100.8 ±1.49	148.7 ±1.74	195.8 ±1.78	252.2 ±1.76	300.2 ±0.40
K^{40} CPM, live[b]	3641 ± 103	4559 ± 161	5253 ± 107	6007 ± 223	6494 ± 307
Duncan Meter backfat probe, in.[c]	0.59±0.017	0.90±0.031	1.08±0.019	1.27±0.047	1.36±0.096

[a] Twenty-four hours off feed and water.

[b] Average K^{40} counts per minute (mean of ten one-minute counts).

[c] Average of three backfat probes taken approximately 1½ inches off the midline of the back at the first rib, last rib, and last lumbar vertebra.

TABLE IX

MEANS AND STANDARD ERRORS FOR LIVE MEASUREMENTS ON HAMPSHIRES SLAUGHTERED AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Number of animals	14	14	14	14	14
Slaughter wt., lbs.[a]	101.7 ±1.26	148.1 ±1.09	196.8 ±0.98	247.7 ±1.15	299.6 ±1.18
K^{40} CPM, live[b]	3747 ± 45	4887 ± 129	5187 ± 95	6050 ± 148	6171 ± 109
Duncan Meter backfat probe, in.[c]	0.61±0.015	0.81±0.024	1.10±0.030	1.24±0.030	1.43±0.036

[a] Twenty-four hours off feed and water.

[b] Average K^{40} counts per minute (mean of ten one-minute counts).

[c] Average of three backfat probes taken approximately 1½ inches off the midline of the back at the first rib, last rib, and last lumbar vertebra.

K^{40} counts per minute (CPM) ranged from 3641 to 6494 for the Yorkshires and 3747 to 6171 for the Hampshires for the 100 and 300 pound weight groups, respectively. Plots of the relationships between net K^{40} count and slaughter weight are presented in Figures 2 and 3 for the Yorkshires and Hampshires, respectively. Individual pigs in both breeds were K^{40} evaluated when they reached each live weight interval. The solid lines in both figures present the plot of data for all pigs in both breeds that were K^{40} evaluated at these weights, including those not slaughtered. The plot of the K^{40} counts for the Hampshires indicate that the pigs slaughtered at different weights appear to have been quite representative of all the Hampshire pigs K^{40} evaluated at that weight since average net K^{40} counts were similar. This trend was not observed in the Yorkshires (Figure 2) as the mean K^{40} count for all Yorkshires counted at a specific weight was higher than the mean K^{40} count for those Yorkshires counted and slaughtered at that weight. This suggests that the pigs not slaughtered at the lighter weights were leaner than those actually slaughtered. A portion of the observed difference in mean K^{40} count between all Yorkshires K^{40} evaluated and those evaluated and then slaughtered may also be attributed to chance.

As was expected, live K^{40} counts per minute increased as slaughter weight increased. A rather linear trend is observed for mean K^{40} counts per minute for the Yorkshires (Figure 2) from 100 to 250 pounds with a decline in rate of

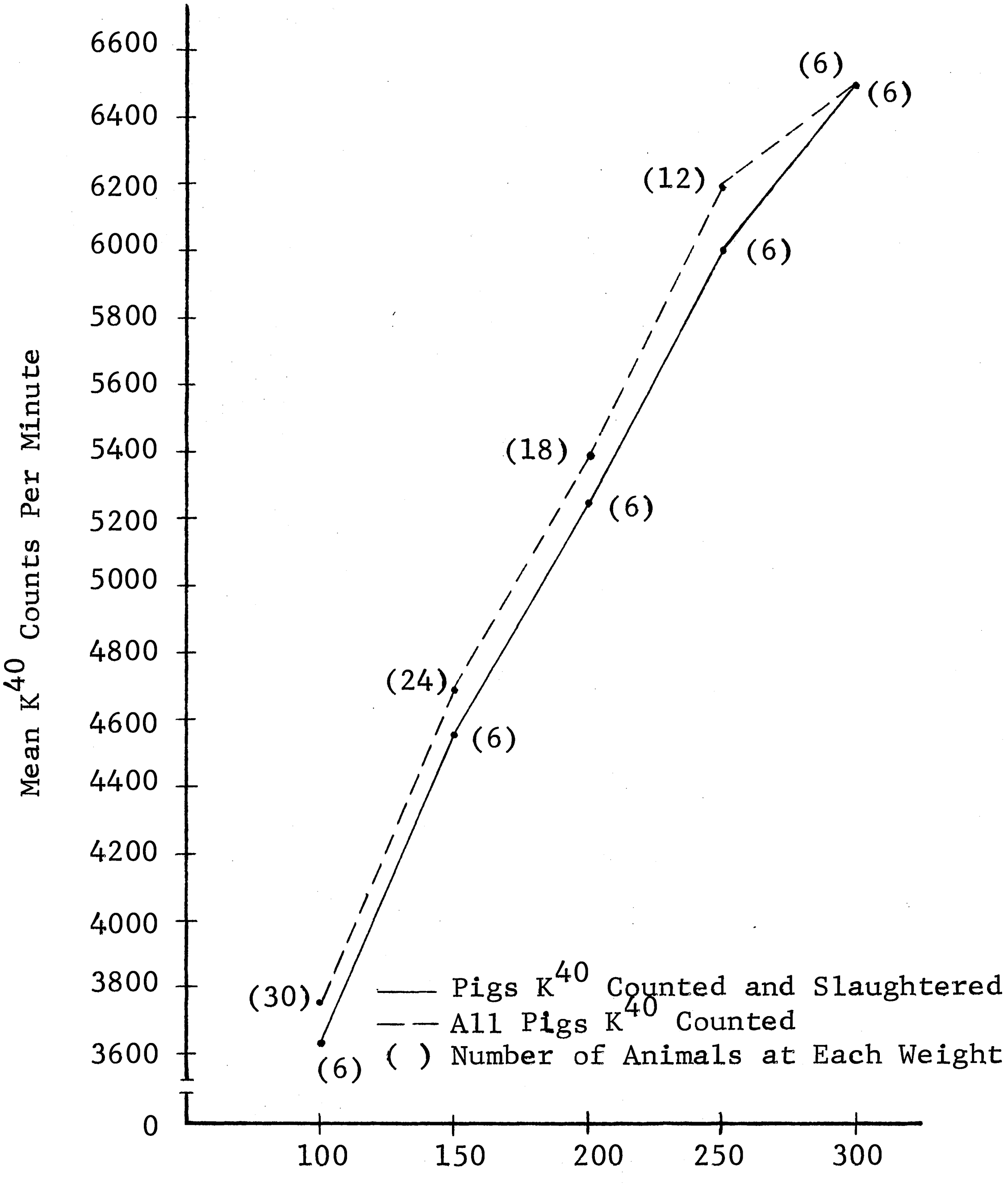

Figure 2. Mean K^{40} Counts Per Minute for Yorkshire Pigs Slaughtered and for All Yorkshire Pigs K^{40} Evaluated at Five Weight Groups.

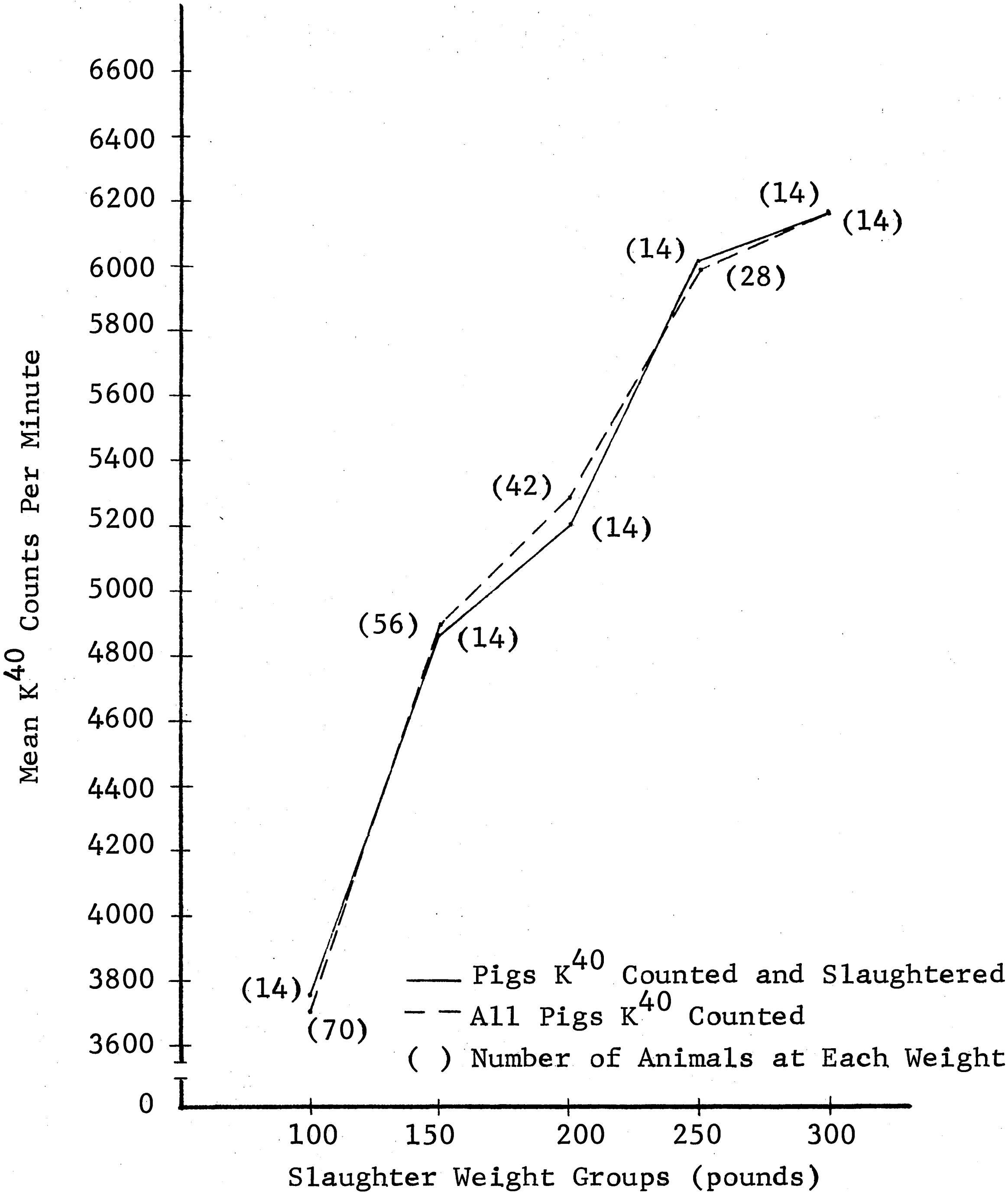

Figure 3. Mean K^{40} Counts Per Minute for Hampshire Pigs Slaughtered and for All Hampshire Pigs K^{40} Evaluated at Five Weight Groups.

increased mean K^{40} count occurring from 250 to 300 pounds. As shown in Table VII, slaughter weight did account for a significant ($P \leq .01$) amount of the variation found in mean K^{40} count. In addition, linearity accounted for 98.5 percent of the total sums of squares, thereby suggesting that there was a linearlike response and that little or no important non-linear responses occurred.

It appears that a linearlike response for mean K^{40} count was not as prevalent in the Hampshire data as in the Yorkshire data (Figure 3). In fact, a quadratic response was observed with the rate of increase in K^{40} count tending to decline with increased slaughter weight, especially from 250 to 300 pounds. As illustrated in Figures 2 and 3, the most rapid increase in net K^{40} count per minute for both breeds occurred between the 100 and 150 pound weights, and the smallest increase in K^{40} count occurred between the 250 and 300 pound weight interval for both breeds. This ovservation is in agreement with Moser (1970) who reported similar results in a study involving sixty Yorkshire barrows.

The small increase in net K^{40} count from 250 to 300 pounds may be attributed to the self-absorption (in relation to mass) of gamma rays emitted from the muscle in the animals. The larger the animal, the greater is the likelihood that a gamma ray will lose part of its energy before leaving the animal and interacting with the detectors, thus reducing the number of disintegrations detected. The small increase in net K^{40} count from 250 to 300 pounds may also be due to the possible "shielding" effect of fat against the transmission of radiation energy from whole-body potassium, especially since there was considerably more subcutaneous fat (backfat) in the 300 pound than in the 150 pound pigs. These two possible explanations are further substantiated when mean K^{40} counts per minute per pound of fat-free lean at five different weights were plotted for both breeds (Figure 4). As slaughter weight increased, mean K^{40} counts per minute per pound of fat-free lean decreased for both breeds (Appendix Table LIX). Since an actual increase in fat-free lean occurred with increased weight, then it appears that the gamma rays emitted from the lean were not reaching the detectors and were, therefore, not being K^{40} counted.

In an effort to estimate backfat thickness, a live probe was taken on each pig prior to slaughter using a Duncan Lean Meter. The average backfat thickness estimated by the Duncan Lean Meter ranged from 0.59 to 1.36 inches for the Yorkshires and from 0.61 to 1.43 inches for the Hampshires (Tables VIII and IX). Linearity accounted for 95.8 percent of the total sums of squares for the Yorkshires and 98.9 percent in the Hampshire data. This strongly suggests that the principle relationship between live backfat probe and weight for both breeds was linearlike. The non-linear response, even though significant ($P \leq .01$) for both breeds (Table VII), accounted for only 4.1 percent and 1 percent of

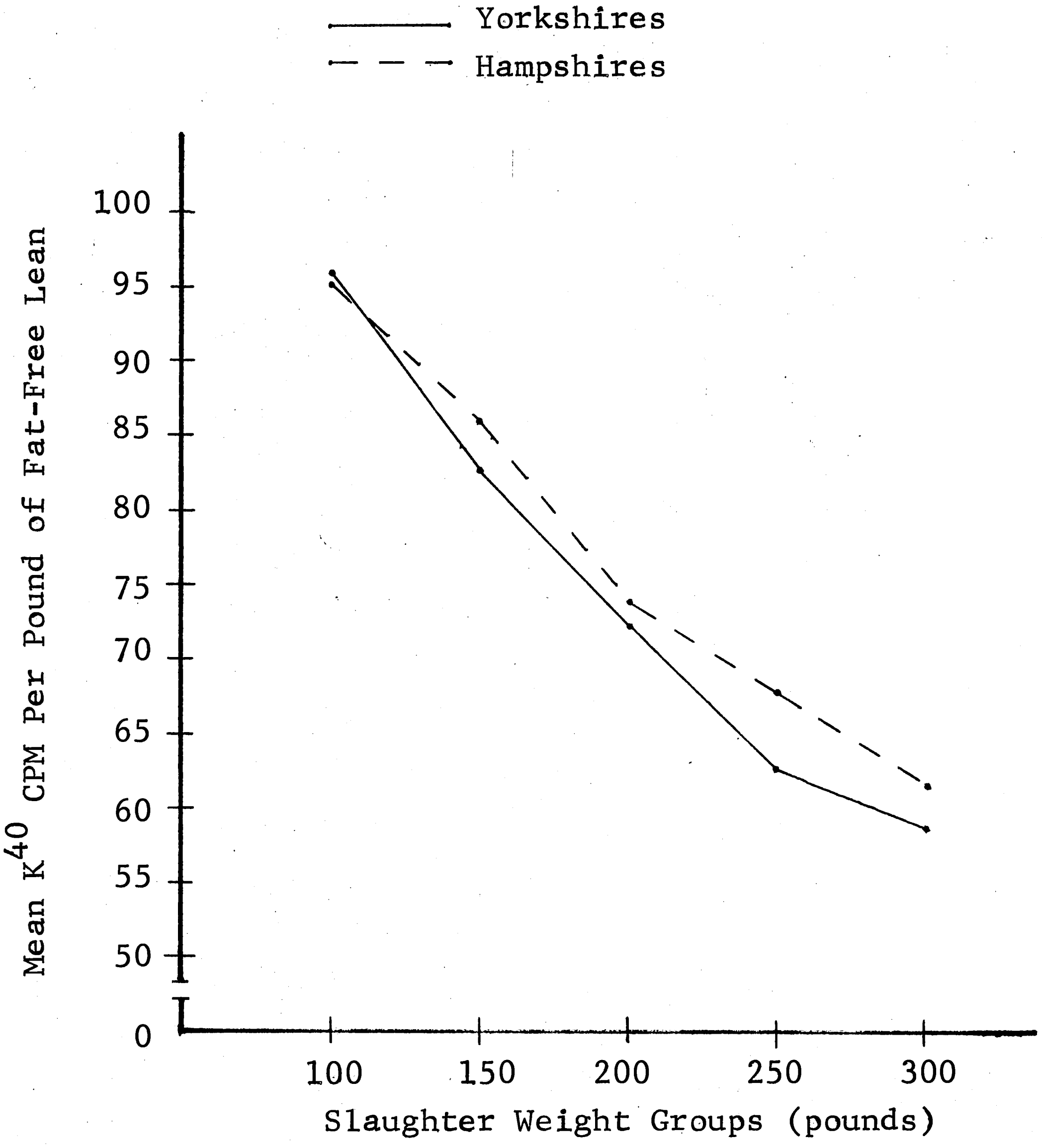

Figure 4. Mean K^{40} Counts Per Minute Per Pound of Fat-Free Lean for Yorkshire and Hampshire Pigs at Different Weights.

the total sums of squares for the Yorkshires and Hampshires, respectively, indicating a weak non-linear response between live backfat probe and weight.

Carcass Measurements

Means and standard errors for carcass measurements obtained from pigs slaughtered at different weights are presented in Tables X and XI for Yorkshires and Hampshires, respectively.

Mean carcass backfat thicknesses ranged from 0.62 to 1.28 inches and from 0.62 to 1.41 inches for the Yorkshires and Hampshires, respectively. The plot presented in Figure 5b suggests a strong linear relationship between carcass backfat and weight in the Hampshires. An average increase in carcass backfat of 0.19 inches occurred for each 50 pound increase in slaughter weight. In addition, linearity ($P \leq .01$) accounted for 99.6 percent of the total sums of squares (Appendix Tables XXXV and XXXVI), further substantiating the strong linearlike response observed for carcass backfat in the Hampshire data. A quite different response curve for carcass backfat was observed for the Yorkshires. As illustrated in Figure 5b, the rate of increase in carcass backfat for the Yorkshires tended to decrease with increased live weight from 150 to 300 pounds, indicating a non-linear ($P \leq .01$) response.

Carcass backfat was similar at the five weights for both breeds except at the 300 pound weight group where the

TABLE X

MEANS AND STANDARD ERRORS FOR CARCASS MEASUREMENTS OF YORKSHIRE PIGS AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Number of animals	6	6	6	6	6
Carcass wt., lbs.	68.0 ±2.54	103.0 ±1.65	141.7 ±1.81	187.0 ±4.11	222.9 ±1.55
Backfat, in.	0.62±0.02	0.93±0.03	1.14±0.04	1.26±0.03	1.28±0.09
Loin eye area, sq. in.	2.62±0.09	3.75±0.15	4.49±0.09	5.35±0.40	6.18±0.21
Carcass length, in.	25.3 ±0.24	28.2 ±0.21	30.5 ±0.20	32.4 ±0.40	34.3 ±0.32
Dressing percent	67.4 ±1.78	69.2 ±0.59	72.4 ±0.53	74.1 ±1.20	74.3 ±0.49

TABLE XI

MEANS AND STANDARD ERRORS FOR CARCASS MEASUREMENTS OF HAMPSHIRE PIGS AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Number of animals	14	14	14	14	14
Carcass wt., lbs.	68.5 ±1.20	104.4 ±1.05	141.0 ±1.10	184.6 ±1.07	223.2 ±1.51
Backfat, in.	0.62±0.03	0.80±0.03	1.05±0.04	1.19±0.03	1.41±0.04
Loin eye area, sq. in.	3.14±1.23	4.30±0.18	5.02±0.18	5.83±0.17	5.77±0.16
Carcass length, in.	24.8 ±0.21	27.8 ±0.18	29.7 ±0.17	31.7 ±0.18	33.2 ±0.24
Dressing percent	67.3 ±0.69	70.5 ±0.44	71.7 ±0.37	74.5 ±0.33	74.5 ±0.28

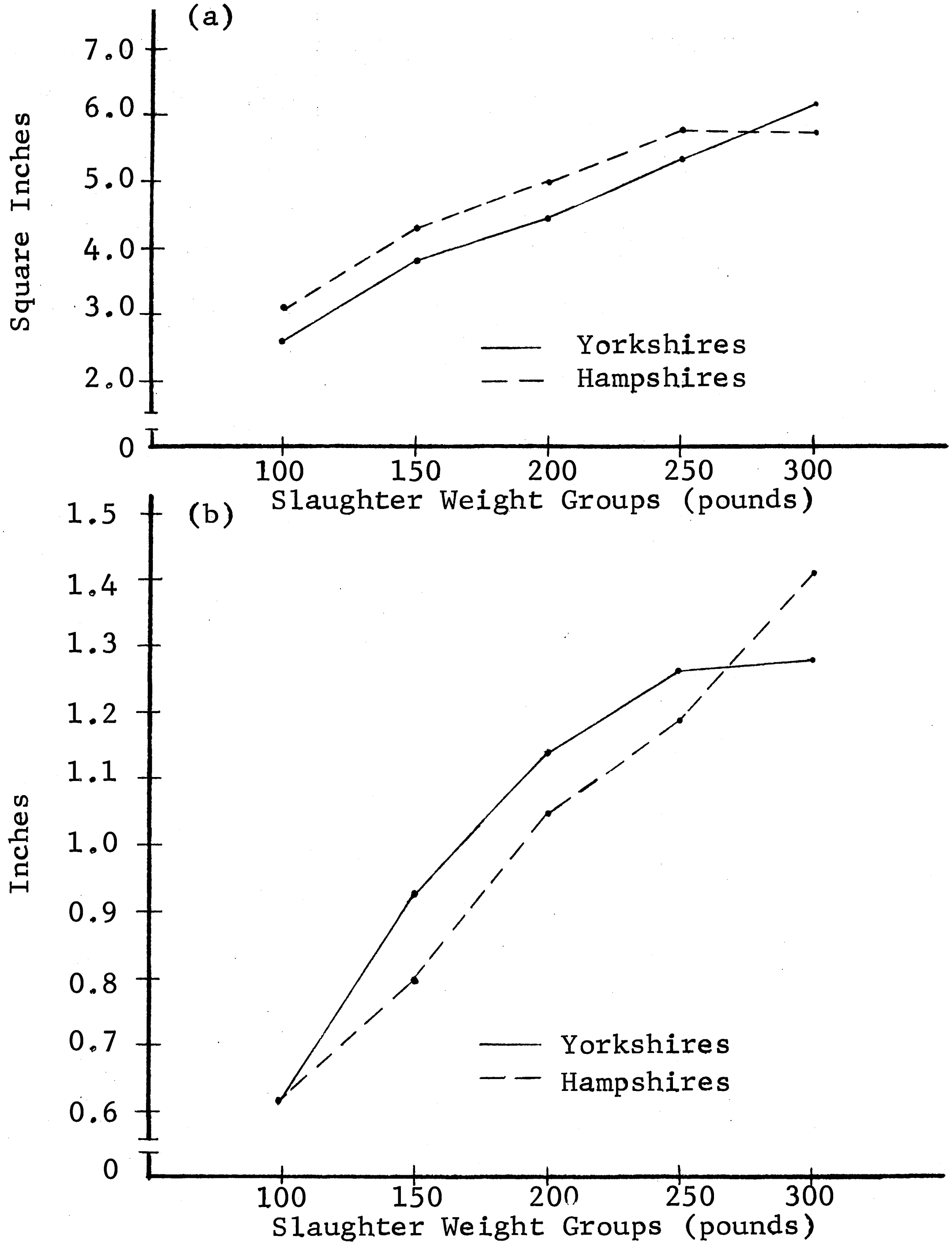

Figure 5. Carcass Loin Eye Area (a) and Backfat Thickness (b) for Yorkshire and Hampshire Pigs at Different Weights.

Hampshires averaged 1.41 inches compared to 1.28 inches of backfat for the Yorkshires. The Yorkshires increased 0.02 inches in backfat from 250 to 300 pounds live weight, while the Hampshires increased 0.22 inches. Although 0.2 of an inch in backfat is not a great difference between pigs of the same live weight, it suggests that the Hampshires were laying down more subcutaneous fat and developing less muscle at 300 pounds than were the Yorkshires. The response curve for backfat in the Hampshires was quite similar to the "Classic" growth curves of subcutaneous fat deposition in swine with increased age or live weight. The slowest rate of fat deposition was observed from 100 to 150 pounds, while the most rapid increase in backfat thickness occurred from 250 to 300 pounds. These results are as expected and are in agreement with most growth studies involving pigs (Allen _et_ _al_., 1961, and Zobrisky, 1963). The opposite trend was observed for backfat thickness in the Yorkshires. The most rapid increase in backfat thickness occurred from 100 to 150 pounds live weight, while the least increase was found at the 250 to 300 pound interval. The backfat response curve for the Yorkshires (presented in Figure 5b) is atypical of backfat growth patterns normally found in present day market hogs. This unusual backfat response found in the Yorkshires must be kept in mind when interpreting results from this study since fat is such a major part of composition. This data suggests that the Yorkshire pigs used in this study were late maturing pigs that utilized most of their excess energy for the deposition of lean rather than fat, especially at the heavier weights.

Loin eye area increased as slaughter weight increased in both breeds, except in the 250 to 300 pound interval for the Hampshires. The plot presented in Figure 5a suggests a strong linear association between loin eye area and weight in the Yorkshires. Increases in loin eye area were 1.13, 0.74, 0.82, and 0.86 square inches for the intervals of 100-150, 150-200, 200-250, and 250-300 pounds, respectively, indicating a rather constant increase in loin eye area with increased weight. As illustrated in Figure 5a, a similar relationship between loin eye area and weight was observed from 100 to 250 pounds in the Hampshires; however, a leveling-off of the response curve occurred from 250 to 300 pounds live weight. Increases in loin eye area were 1.16, 0.72, and 0.81 square inches for the intervals of 100-150, 150-200, and 200-250 pounds, respectively, indicating a moderately linear response with respect to loin eye area. However, no apparent increase in loin eye area was observed in the Hampshires from 250 to 300 pounds and this fact was primarily responsible for the significant ($P \leq .01$) nonlinear response found in the Hampshire data (Appendix Table XXXVI).

The largest increases in loin eye area for both breeds occurred between 100 and 150 pounds live weight as shown in Figure 5a. These trends were as expected and agreed with results reported by Allen *et al.* (1961), Zobrisky (1963), and Moser (1970) in similar studies. Breed differences became evident at the 250 to 300 pound interval as the Yorkshires continued to increase in loin eye area at a rather rapid rate, while no increase was found in loin eye area of the Hampshires from 250 to 300 pounds live weight. These data may indicate that the Hampshires reached the peak of their growth curve at 250 pounds live weight. Loin eye areas normally increase with increased weight or age; however, the rate of increase generally declines as the animals approach heavier live weights. This trend was observed in the Hampshires, but the Yorkshires continued to increase in loin eye area at a growth rate similar to those at the lighter weights. This trend again illustrates the unusual growth response associated with this family of Yorkshires, even though limited numbers were used in the study.

Carcass length increased as slaughter weight increased in both breeds. The association between carcass length and weight is illustrated in Figure 6. The linearlike response curve of Yorkshire carcass length observed in Figure 6 was a result of the rather constant increase in carcass length, especially from 150 to 300 pounds. Carcass length increased 2.3, 1.9, and 1.9 inches for the intervals of 150-200, 200-250, and 250-300 pounds, respectively. A curvilinear response was apparent in the plot of Hampshire carcass length as presented in Figure 6. A definite decline in rate of increased carcass length occurred from 150 to 300 pounds

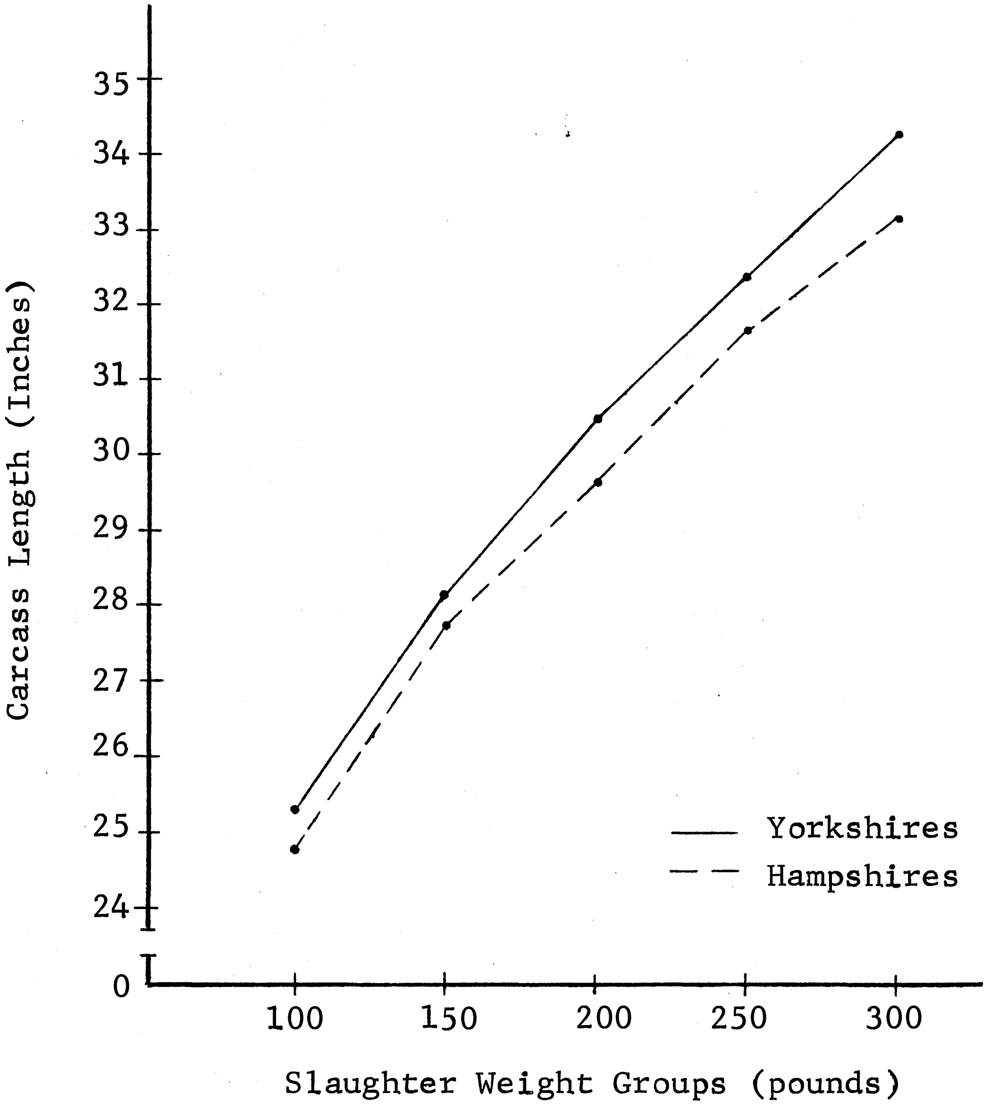

Figure 6. Mean Carcass Length for Yorkshire and Hampshire Pigs at Different Weights.

live weight. An obvious decline (Figure 6) in rate of increased carcass length occurred from 100 to 150 pounds, followed by a linear increase in carcass length from 150 to 250 pounds, and then another definite decline in rate of increased carcass length from 250 to 300 pounds. These varied responses in carcass length with increased slaughter weight were responsible for the significant non-linear trend observed in the Hampshire data.

The order of tissue growth follows a sequential trend starting with the central nervous system and progressing to bone, tendon, muscle, intermuscular fat, and intramuscular fat (Palson and Verges, 1952; McMeekan, 1959). Since bone is the first tissue to develop, one would expect a decline in rate of increased length as an animal matures and increases in weight. It is suggested from Figure 6 that the Yorkshires were increasing in length at a faster rate, especially at the heavier weights, than were the Hampshires. This observation indicates that the Hampshires may have been approaching maturity insofar as skeletal growth is concerned, while the Yorkshires were still increasing in length at near maximum skeletal growth capacity at 300 pounds live weight.

Rather strong linear relationships ($P \leq .01$) were found between live weight and dressing percent for both breeds (Appendix Tables XXXV and XXXVI). These results were as expected since dressing percent generally increases with an increase in live weight. Similar results were reported by Moser (1970) and Zobrisky (1963).

Carcass Composition

Fat-free lean was used as the compositional end point for lean in this study since this trait would most closely represent the true lean composition of the pigs. There are very few pork composition studies reported in the literature in which large numbers of carcasses were completely dissected into lean, fat, and bone, as was the case in this study. It must be emphasized that great care was used in removing subcutaneous and intermuscular fat from the lean and in conducting precise ether-extract analyses in order to obtain an accurate estimate of fat-free lean for each of the 100 pigs.

Means and standard errors for fat-free lean, fat, and bone, for both breeds, expressed as pounds are presented in Table XII. Pounds of fat-free lean, fat, and bone increased as slaughter weight increased for both breeds, with fat increasing more rapidly in the heavier weights, especially in the Hampshires. Mean pounds of fat-free lean, fat, and bone for both Yorkshires and Hampshires are presented in Figure 7. Pounds of fat-free lean increased rather rapidly from 100 to 300 pounds and the rate of increase appeared to be linearlike for both breeds (Figure 7). Pounds of fat-free lean appeared to be linear for both breeds from 100 to 250 pounds; however, a slight decline in rate of increased pounds of fat-free lean occurred from 250 to 300 pounds for both breeds. A significant ($P \leq .05$) non-linear response was

TABLE XII

MEANS AND STANDARD ERRORS FOR CARCASS COMPONENTS, EXPRESSED AS POUNDS, FOR YORKSHIRES AND HAMPSHIRES AT DIFFERENT SLAUGHTER WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Yorkshires					
Number	6	6	6	6	6
Fat-free lean, lbs.	38.0±1.89	55.1±2.14	72.7±0.76	96.1±3.79	110.8±2.63
Fat, lbs.[a]	17.3±1.38	30.3±2.05	47.3±2.80	64.6±2.63	82.1±3.96
Bone, lbs.	12.7±0.73	16.0±0.22	21.1±0.91	25.6±0.76	28.9±1.09
Hampshires					
Number	14	14	14	14	14
Fat-free lean, lbs.	39.2±0.96	56.9±1.13	70.2±1.37	89.2±1.83	100.5±2.07
Fat, lbs.	16.9±0.96	30.9±1.25	50.4±1.75	70.6±2.03	95.7±2.31
Bone, lbs.	12.1±0.39	16.1±0.44	19.8±0.41	24.2±0.55	27.5±0.45

[a] Trimmable fat plus percent ether-extractable materials in separable lean.

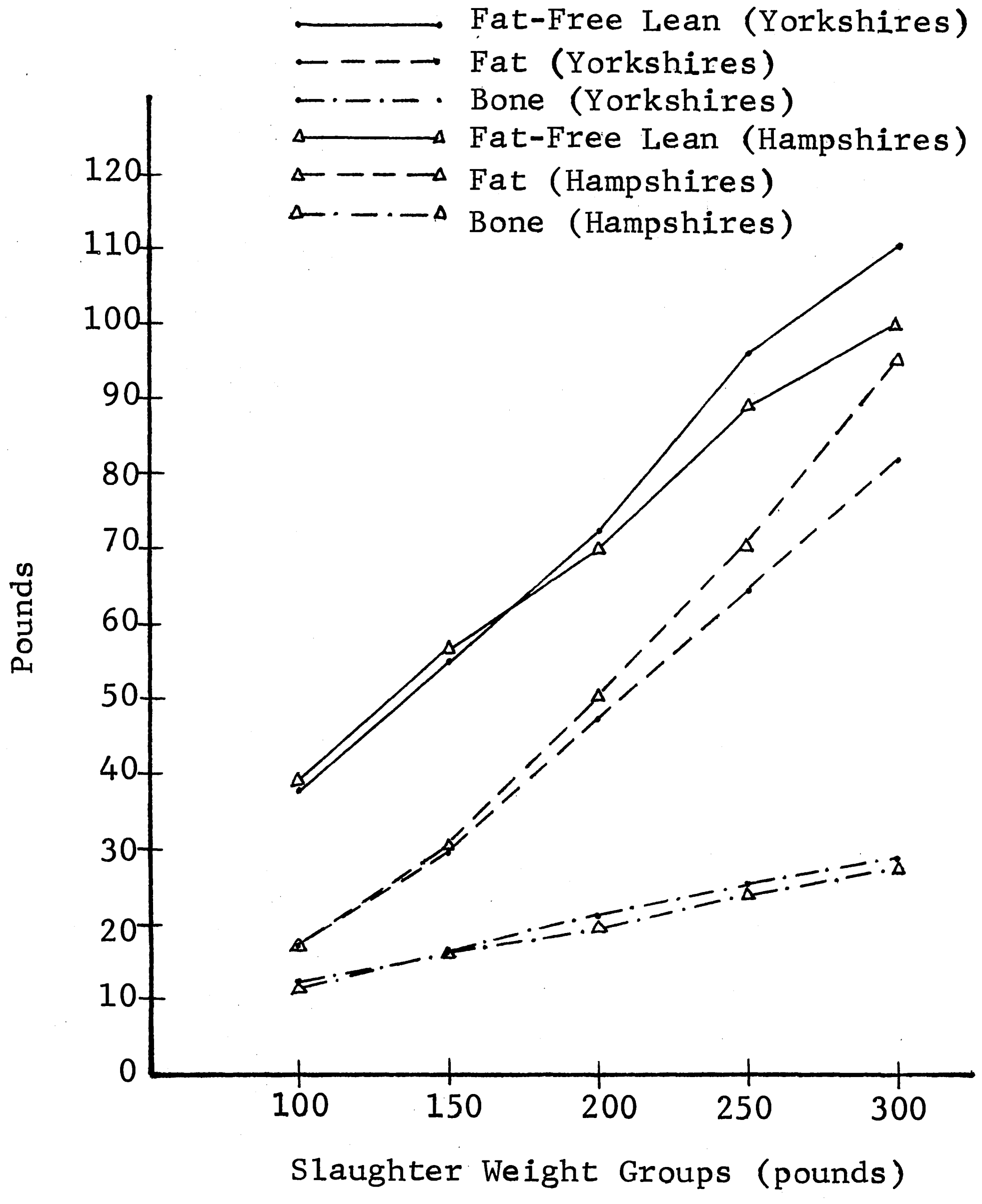

Figure 7. Mean Pounds of Fat-Free Lean, Fat, and Bone from Yorkshire and Hampshire Pigs at Five Different Weights.

observed in the Hampshire data (Appendix Table XXXVI); however, such a response was not found in the Yorkshire data (Appendix Table XXXV).

The average difference between weight groups for pounds of fat-free lean are presented in Appendix Tables LI and LII for Yorkshires and Hampshires, respectively. The stage of most rapid muscular development was found to be from 200 to 250 pounds for both breeds, and the least from 250 to 300 pounds for both Yorkshires and Hampshires. These observations are further illustrated in Figure 7 as shown by the slope changes in the response curves for fat-free lean at the different weights. Moser (1970) in a similar study, found the stage of most rapid muscular development to occur from 100 to 150 pounds live weight. These observations further substantiate the muscle developing capacity of the pigs used in this study, especially at heavier weights.

Mean pounds of fat appeared to be linear for both breeds, especially from 150 to 300 pounds. The response curve for fat in the Yorkshires was especially linearlike as increases in fat of 13.0, 17.0, 17.3, and 17.5 pounds were observed for the slaughter weight intervals 100-150, 150-200, 200-250, and 250-300 pounds, respectively. This response for fat is rather unusual, especially at the heavier weights, since fat deposition generally increases at a fairly rapid rate as market hogs reach the 200 to 250 pound interval. On the other hand, after observing the non-linear response for carcass backfat in the Yorkshires, one would logically expect a linearlike response for total fat due to the geometrical relationships between subcutaneous, intermuscular, and intramuscular fat.

An increasing slope of the response curve with each increasing weight interval (Figure 7) suggests a non-linear trend for fat in the Hampshire data. Increases in fat of 14.0, 19.5, 20.2, and 25.1 pounds were observed for the slaughter weight intervals of 100-150, 150-200, 200-250, and 250-300 pounds, respectively, further illustrating the increased rate of fat deposition with increased slaughter weight. The fat response curve for the Hampshires was similar to the "Classic" curvilinear response generally associated with market hogs.

The stage of most rapid fat deposition occurred from 250 to 300 pounds, while the least occurred from 100 to 150 pounds for both breeds. These trends for fat deposition were as expected. It is interesting to note that the Yorkshire pigs increased in fat deposition 0.5 pounds from 150 to 300 pounds, compared to 5.6 pounds for the Hampshires for the same weight range.

The bone growth pattern appeared to be linear for both breeds as illustrated in Figure 7. An average increase of 4.0 pounds for each 50 pound increase in slaughter weight was observed for both breeds. Very little difference in total bone at each weight was noted between the two breeds (Figure 7).

The means and standard errors for fat-free lean, fat, and bone, expressed as percent carcass weight, are presented in Table XIII for both breeds. These components are also expressed on a percent slaughter weight basis in Appendix Tables XLI and XLII. However, only discussion of the components expressed on a carcass weight basis will be included since discrepancies in composition, when expressed on a percent slaughter weight versus percent carcass weight basis, are due to either real or chance differences in dressing percent.

Generally, fat-free lean expressed as a percentage of carcass weight, decreased as slaughter weight increased for both breeds. Fat-free lean, expressed on a carcass weight basis, appeared to be linear for the Yorkshires from 100 to 200 pounds; however, very little decrease in fat-free lean occurred from 200 to 300 pounds. This indicated that the Yorkshire pigs were continuing to develop muscle at a rate similar to that of increased slaughter weight. This trend is rather unusual further indicating the superior muscle developing capacity of the Yorkshire pigs used in this study.

Weight was found to have a significant ($P \leq .01$) effect on fat, when expressed as a percentage of carcass weight, for both breeds (Appendix Tables XXXV and XXXVI). An apparent breed difference occurred from 200 to 300 pounds, with fat (expressed as a percentage of carcass weight) increasing at a more rapid rate in the Hampshires than in the Yorkshires at the heavier weights.

TABLE XIII

MEANS AND STANDARD ERRORS FOR CARCASS COMPONENTS, EXPRESSED AS PERCENT CARCASS WEIGHT, FOR YORKSHIRES AND HAMPSHIRES AT DIFFERENT SLAUGHTER WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Yorkshires					
Number	6	6	6	6	6
FFL-% carcass wt., lbs.	56.0±2.09	53.5±1.94	51.4±1.06	51.4±1.38	49.8±1.33
Fat-% carcass wt., lbs.[a]	25.4±1.48	29.5±2.06	33.3±1.64	34.6±1.48	36.8±1.60
Bone-% carcass wt., lbs.	18.6±0.98	15.6±0.22	14.9±0.71	13.7±0.21	13.0±0.53
Hampshires					
Number	14	14	14	14	14
FFL-% carcass wt., lbs.	57.4±1.26	54.6±1.11	49.8±1.05	48.3±0.91	45.1±0.95
Fat-% carcass wt., lbs.	24.6±1.19	29.5±1.04	35.7±1.12	38.3±1.10	42.9±0.95
Bone-% carcass wt., lbs.	17.7±0.40	15.5±0.45	14.0±0.28	13.1±0.31	12.3±0.25

[a] Trimmable fat plus percent ether-extractable materials in separable lean.

Pounds of bone, when expressed as a percentage of carcass weight, tended to decrease with increased slaughter weight. The relationship between bone and slaughter weight appeared to be linear for both breeds, especially from 150 to 300 pounds (Figure 8). In fact, an average of 0.7 percent decrease in bone occurred for each 50 pound increase in slaughter weight (from 150 to 300 pounds) for both breeds. There appeared to be very little difference in the two breeds although the Yorkshires had slightly more bone at each different weight when expressed on a carcass weight basis.

The means and standard errors for carcass yields expressed as pounds and as a percentage of carcass weight for Yorkshire and Hampshire pigs at different weights are presented in Table XIV. Pounds of lean cuts, ham and loin, and ham increased as slaughter weight increased for both breeds. Statistical analysis of the data (Appendix Tables XXXV-XXXVIII) indicated that weight had a highly significant ($P \leq .01$) effect upon lean cuts, ham and loin and ham yields when expressed as pounds. The increase in pounds of lean cuts with increased slaughter weight were rather constant from 100 to 250 pounds with rate of increase declining slightly from 250 to 300 pounds for both breeds (Figure 9). For example, increases in lean cuts of 20.4, 20.1, 27.3, and 17.3 pounds were recognized for the intervals 100-150, 150-200, 200-250, and 250-300 pounds, respectively, for the Yorkshires

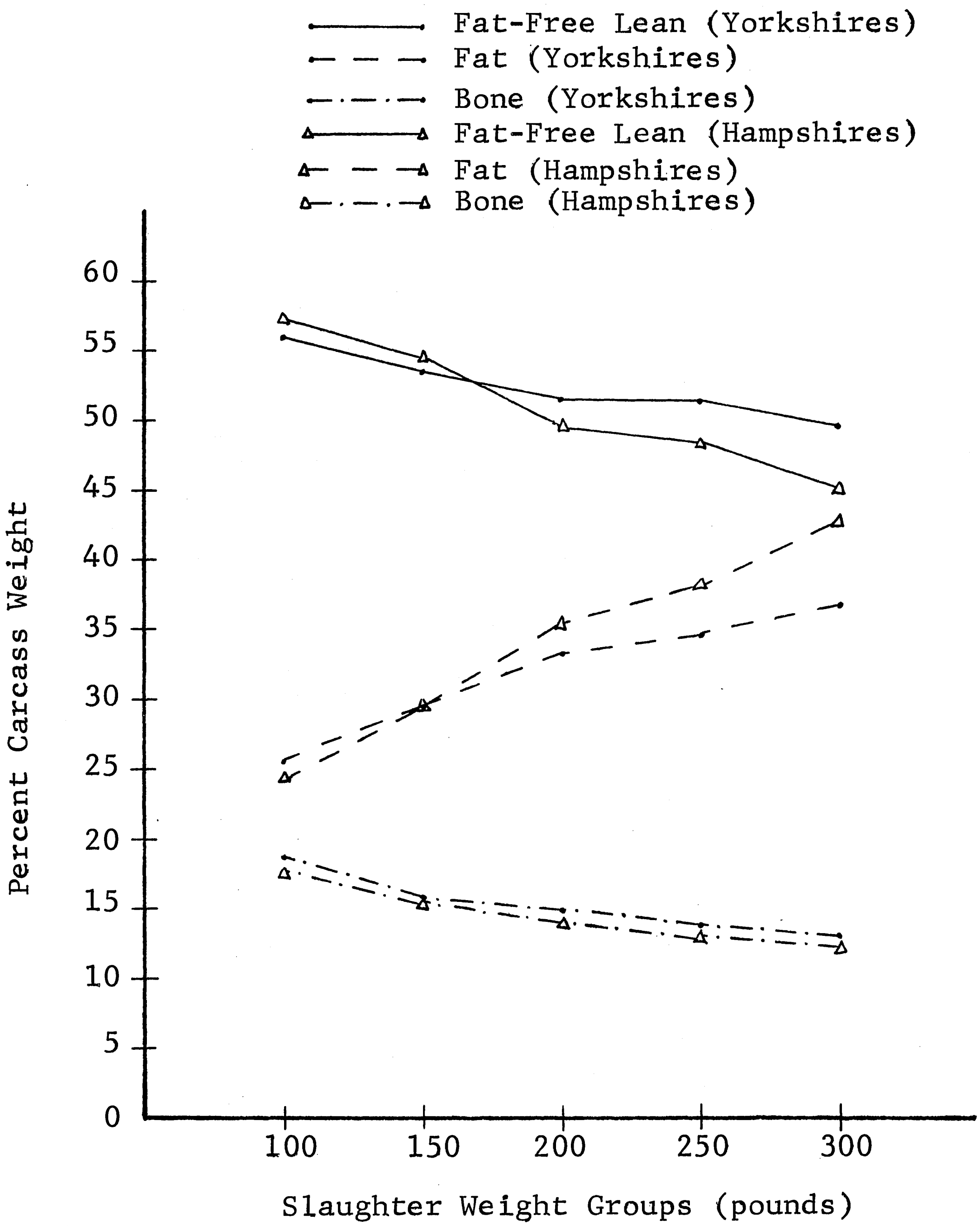

Figure 8. Mean Pounds of Fat-Free Lean, Fat, and Bone, Expressed as Percent Carcass Weight, for Yorkshire and Hampshire Pigs at Five Different Weights.

TABLE XIV

MEANS AND STANDARD ERRORS FOR CARCASS YIELDS EXPRESSED AS POUNDS AND AS A PERCENTAGE OF CARCASS WEIGHT FOR YORKSHIRE AND HAMPSHIRE PIGS AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Yorkshires, 6/wt. group					
Lean cuts, lbs.	42.57±2.05	62.93±1.83	83.03±0.98	110.37±3.81	127.63±3.50
% carcass wt.	62.59±1.80	61.11±1.33	58.67±1.29	58.97±1.18	57.31±1.83
Ham and loin, lbs.	33.50±1.62	50.83±0.72	71.87±1.03	94.53±1.28	113.63±1.45
% carcass wt.	49.23±0.90	49.45±0.84	50.77±0.49	50.65±0.62	51.03±0.75
Ham, lbs.	17.63±0.64	25.67±0.67	35.77±0.62	47.33±1.15	56.53±1.15
% carcass wt.	25.98±0.41	24.98±0.55	25.28±0.30	25.33±0.25	25.40±0.47
Hampshires, 14/wt. group					
Lean cuts, lbs.	44.39±1.08	66.01±1.33	82.41±1.45	106.40±1.66	119.24±2.38
% carcass wt.	64.82±1.18	63.26±1.24	58.49±1.14	57.64±0.81	53.46±1.11
Ham and loin, lbs.	33.83±0.64	51.89±0.69	70.84±0.67	92.13±1.17	113.34±0.93
% carcass wt.	49.43±0.38	49.73±0.41	50.28±0.33	49.94±0.50	50.89±0.49
Ham, lbs.	17.56±0.31	26.23±0.44	34.17±0.39	45.92±0.68	53.06±0.82
% carcass wt.	25.72±0.44	25.17±0.32	24.30±0.36	24.92±0.33	23.82±0.32

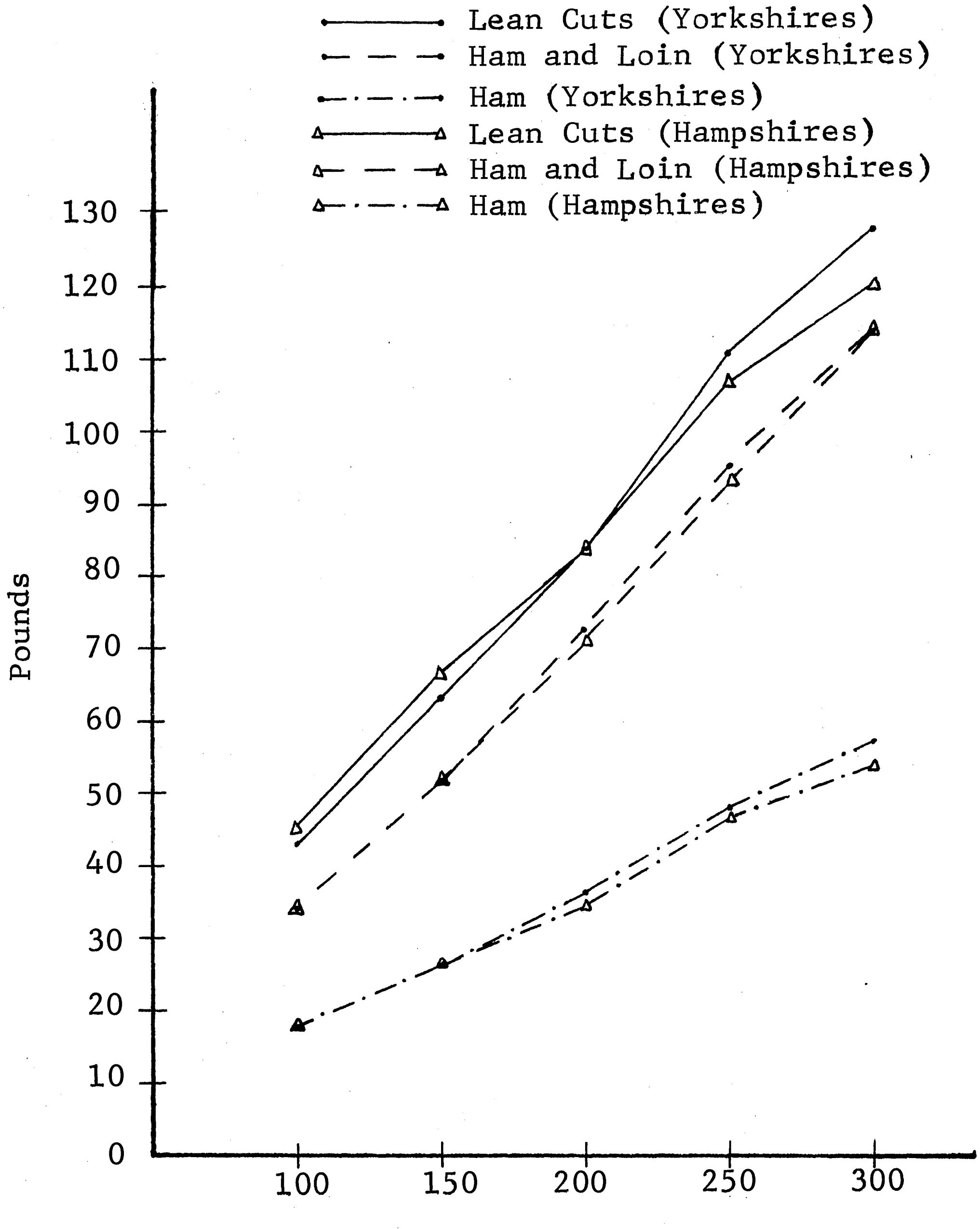

Figure 9. Mean Pounds for Lean Cuts, Ham and Loin, and Ham for Yorkshire and Hampshire Pigs at Different Weights.

The response curves representing pounds of ham and loin for both breeds appear to be quite linearlike as illustrated in Figure 9. A very uniform increase of 19.6 pounds for ham and loin per 50 pound increase in slaughter weight was observed for both breeds. Similar trends were also observed for pounds of ham, with ham yield increasing in a linearlike manner with increased slaughter weight. Linearity ($P \leq .01$) accounted for 99.9 and 99.8 percent of the total sums of squares associated with pounds of ham for Yorkshires and Hampshires, respectively. Very little difference in pounds of ham was observed between the two breeds, especially from 100 to 250 pounds slaughter weight as shown in Figure 9. A slight difference occurred from 250 to 300 pounds with the rate of increase for pounds of ham for the Hampshires starting to decline. This small trend may indicate (along with the slight decline in rate of increase for lean cuts from 250 to 300 pounds) that these Hampshires had reached the peak of their growth curve around 250 pounds.

A slight decrease in pounds of lean cuts (expressed on a carcass weight basis) was observed with increased slaughter weight for both breeds; however, very little change occurred in pounds of ham and loin and ham (expressed as a percentage of carcass weight) with increased slaughter weight for both breeds. These observations are further illustrated in Figure 10. The response curves for ham and loin and ham are nearly horizontal indicating very little if any linear or non-linear effects due to slaughter weight. The statistical

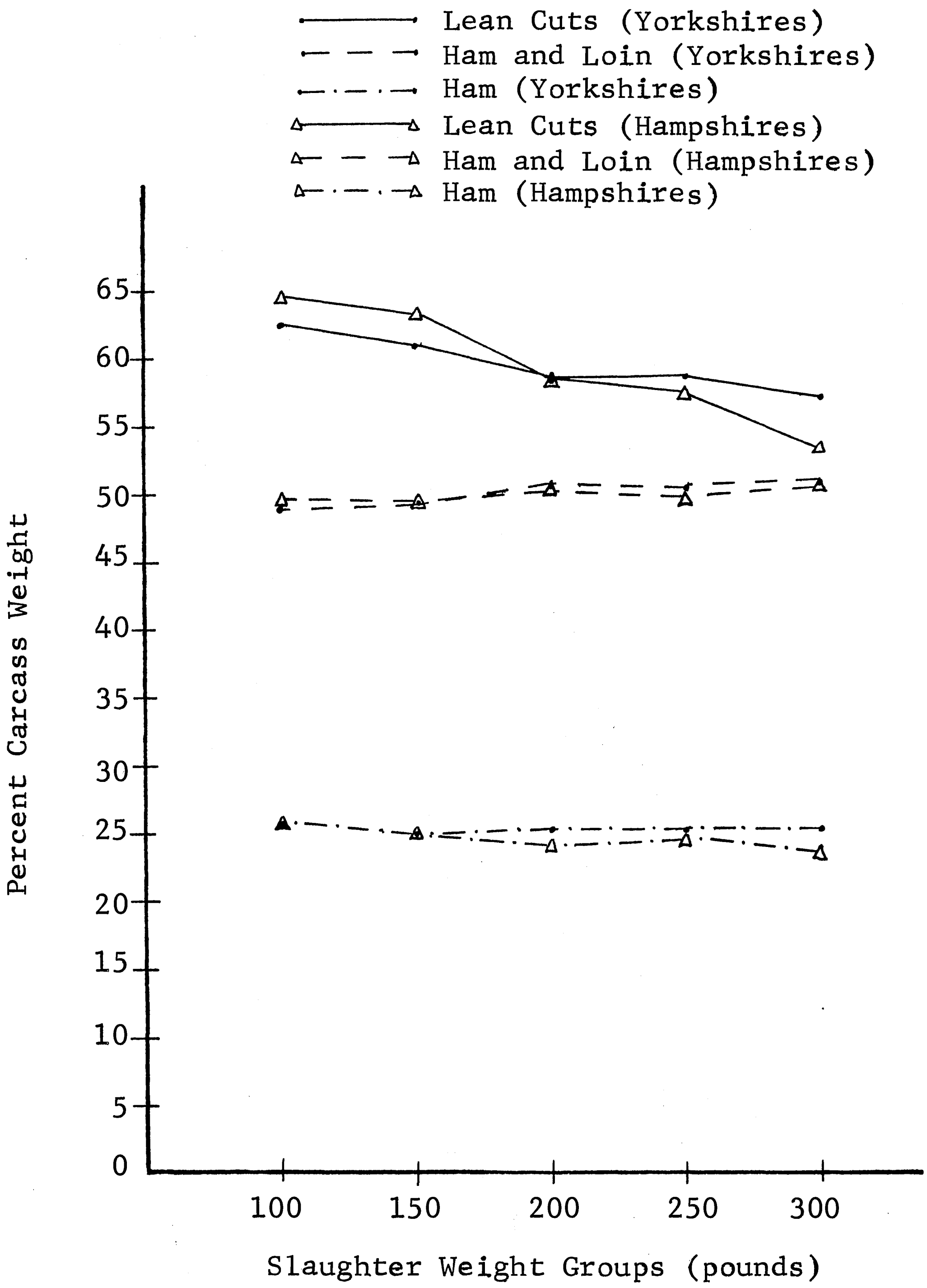

Figure 10. Pounds of Lean Cuts, Ham and Loin, and Ham Expressed as a Percentage of Carcass Weight for Yorkshire and Hampshire Pigs at Different Weights.

analyses of the data for both breeds (Appendix Tables XXXV-XXXVIII) supported the conclusions drawn from the response curves since slaughter weight did not have a significant effect on the yields of lean cuts, ham andloin, and ham when expressed on a carcass weight basis.

These results conflict with those reported by Moser (1970) and Zobrisky et al. (1958) who reported significant linear decreases inlean cuts, ham and loin, and ham yields, when expressed on a carcass weight basis, with increased slaughter weight. Again, the above mentioned observations demonstrate the superior muscle developing capacity of the pigs used in this study, since the yield of lean cuts, ham and loin, and ham were maintained at a constant level (expressed as a percentage of carcass weight) with increased slaughter weight.

Several researchers, including McMeekan (1941), Butterfield (1965), and Orme et al. (1960) have studied specific muscles and groups of muscles in efforts to characterize growth patterns in meat animals. In this study, the biceps femoris and semimembranosus muscles were removed in their entirety from the right side of each pork carcass and individually weighed for purposes of observing some possible trends in muscle development as related to weight.

Means and standard errors for biceps femoris and semimembranosus muscle weights, expressed as pounds, for Yorkshire and Hampshire pigs at different slaughter weights are presented in Table XV. The gross weights for the biceps

TABLE XV

MEANS AND STANDARD ERRORS FOR BICEPS FEMORIS AND SEMIMEMBRANOSUS MUSCLE WEIGHTS EXPRESSED AS POUNDS AND PERCENT CARCASS WEIGHT FOR YORKSHIRE AND HAMPSHIRE PIGS AT DIFFERENT SLAUGHTER WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Yorkshires, 4/wt. group					
Biceps femoris, lbs.	1.20±0.057	1.63±0.169	1.90±0.076	2.85±0.164	3.35±0.139
% carcass wt., lbs.	1.77±0.066	1.59±0.120	1.34±0.052	1.53±0.084	1.51±0.058
Semimembranosus, lbs.	1.00±0.036	1.43±0.123	1.68±0.054	2.55±0.127	2.85±0.152
% carcass wt., lbs.	1.47±0.045	1.39±0.096	1.19±0.043	1.53±0.071	1.28±0.055
Hampshires, 12/wt. group					
Biceps femoris, lbs.	1.14±0.032	1.67±0.046	2.03±0.087	2.66±0.071	3.26±0.090
% carcass wt., lbs.	1.67±0.041	1.60±0.045	1.44±0.049	1.45±0.040	1.46±0.041
Semimembranosus, lbs.	1.08±0.054	1.60±0.073	1.91±0.068	2.43±0.068	2.90±0.099
% carcass wt., lbs.	1.58±0.063	1.54±0.068	1.36±0.042	1.32±0.036	1.30±0.038

femoris and semimembranosus muscles were found to increase as slaughter weight increased for each breed. The average increases in pounds of the biceps femoris and semimembranosus muscles for each 50 pound increase in slaughter weight are presented in Appendix Tables LVII and LVIII for Yorkshires and Hampshires, respectively. The greatest increase in growth for both muscles, when expressed as pounds, occurred at the 200 to 250 pound interval for both breeds. It is interesting to note that the stage of greatest increase in pounds of fat-free lean for each 50 pound increase in slaughter weight was also the 200 to 250 pound weight interval for both breeds.

Slaughter weight was found to have a significant ($P \leq .01$) effect on the gross weight of the two individual muscles (Appendix Tables XXXVII and XXXVIII). In the Yorkshire and Hampshire data, linearity accounted for approximately 92.5 percent of the total sums of squares for both muscle weights of each breed, suggesting a reasonably strong linear relationship between muscle weights and slaughter weight. The response curves presented in Figure 11 appear to be linearlike, especially for the Hampshires where uniform increases in muscle weights with each 50 pound increase in slaughter weight were observed for the individual muscles except for the 150-200 pound interval. Such a uniform increase in muscle weights with increased slaughter weight was not observed in the Yorkshire data; however,

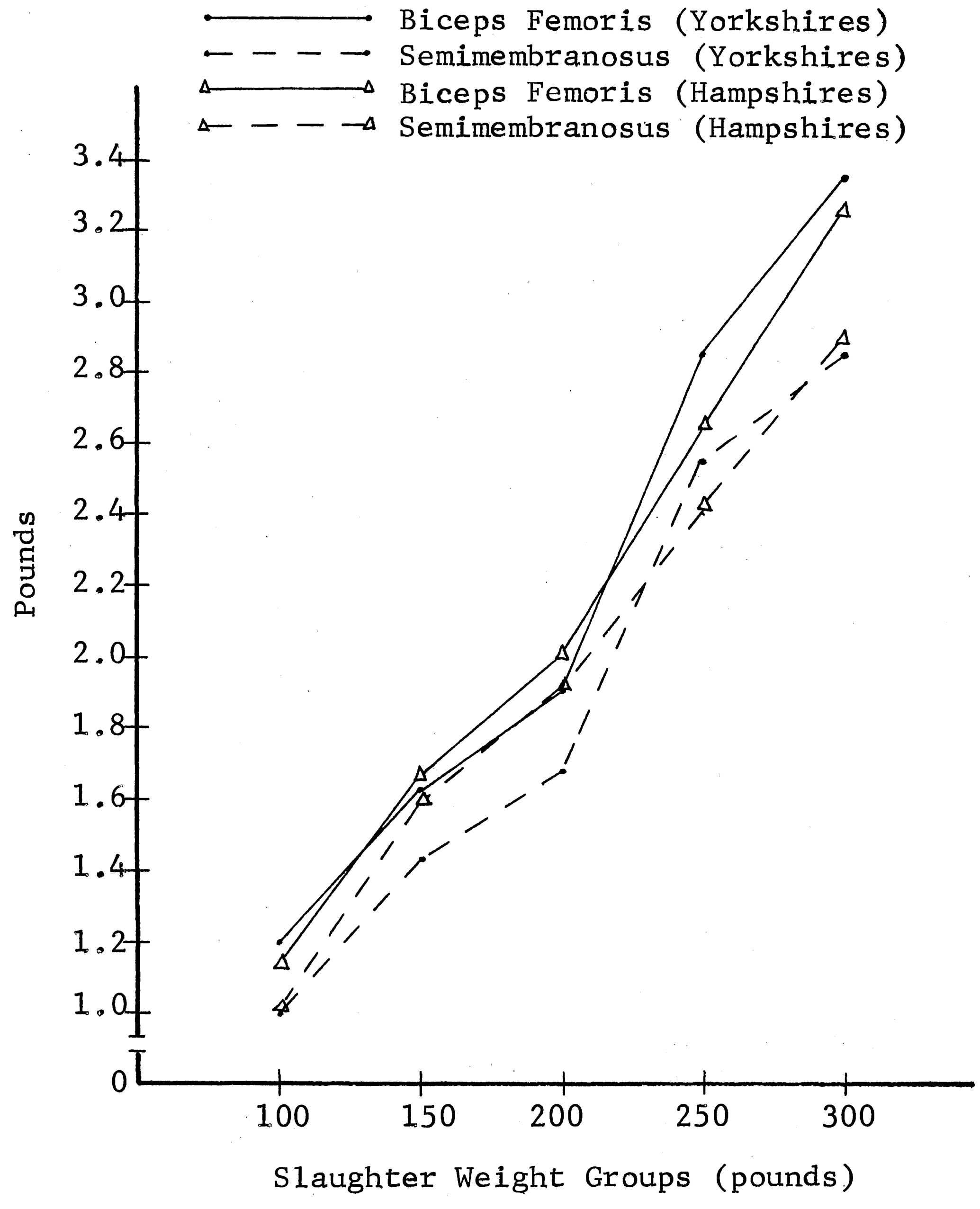

Figure 11. Mean Biceps Femoris and Semimembranosus Muscle Weights Expressed as Pounds for Yorkshires and Hampshires at Different Slaughter Weights.

non-linear effects were not significant nor did they appear to show any pattern for either breed.

Slaughter weight had a significant ($P \leq .05$) effect on biceps femoris and semimembranosus muscle weights, expressed as a percentage of carcass weight, in the Hampshire data as well as the semimembranosus weight in the Yorkshire data. Generally, the muscle weights when expressed as a percentage of carcass weight, decreased with increased slaughter weight.

Means and standard errors for fat-free lean of the biceps femoris and semimembranosus muscles, expressed as pounds and percent slaughter weight, are presented in Table XVI for both Yorkshires and Hampshires. Pounds of fat-free lean for the two individual muscles were found to increase with increased slaughter weight. Again, the greatest increase in pounds of fat-free lean for the individual muscles of both breeds occurred from 200 to 250 pounds.

Slaughter weight was found to have a significant effect on the fat-free lean content of the biceps femoris and semimembranosus muscles for both breeds (Appendix Tables XXXVII and XXXVIII). The response curves for fat-free lean of muscles appear to be linearlike (Figure 12), especially in the Hampshire data where rather constant increases in pounds of fat-free lean (0.5, 0.3, 0.49, 0.45 and 0.48, 0.33, 0.58, 0.50 for biceps femoris and semimembranosus muscles, respectively) occurred for each 50 pound increase in

TABLE XVI

MEANS AND STANDARD ERRORS FOR FAT-FREE LEAN OF THE BICEPS FEMORIS AND SEMIMEMBRANOSUS MUSCLES EXPRESSED AS POUNDS AND PERCENT CARCASS WEIGHT FOR YORKSHIRE AND HAMPSHIRE PIGS AT DIFFERENT SLAUGHTER WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Yorkshires, 4/wt. group					
Biceps femoris, lbs.	0.98±0.035	1.43±0.101	1.61±0.056	2.46±0.129	2.74±0.145
% carcass wt., lbs.	1.45±0.055	1.39±0.099	1.14±0.040	1.32±0.058	1.23±0.058
Semimembranosus, lbs.	1.14±0.052	1.57±0.160	1.79±0.065	2.71±0.143	3.19±0.111
% carcass wt., lbs.	1.68±0.070	1.53±0.150	1.27±0.045	1.45±0.066	1.44±0.051
Hampshires, 12/wt. group					
Biceps femoris, lbs.	1.04±0.049	1.54±0.068	1.83±0.061	2.32±0.065	2.77±0.095
% carcass wt., lbs.	1.52±0.047	1.48±0.049	1.30±0.038	1.26±0.034	1.25±0.039
Semimembranosus, lbs.	1.08±0.027	1.56±0.041	1.89±0.081	2.47±0.067	3.03±0.094
% carcass wt., lbs.	1.58±0.035	1.50±0.036	1.34±0.041	1.34±0.037	1.36±0.038

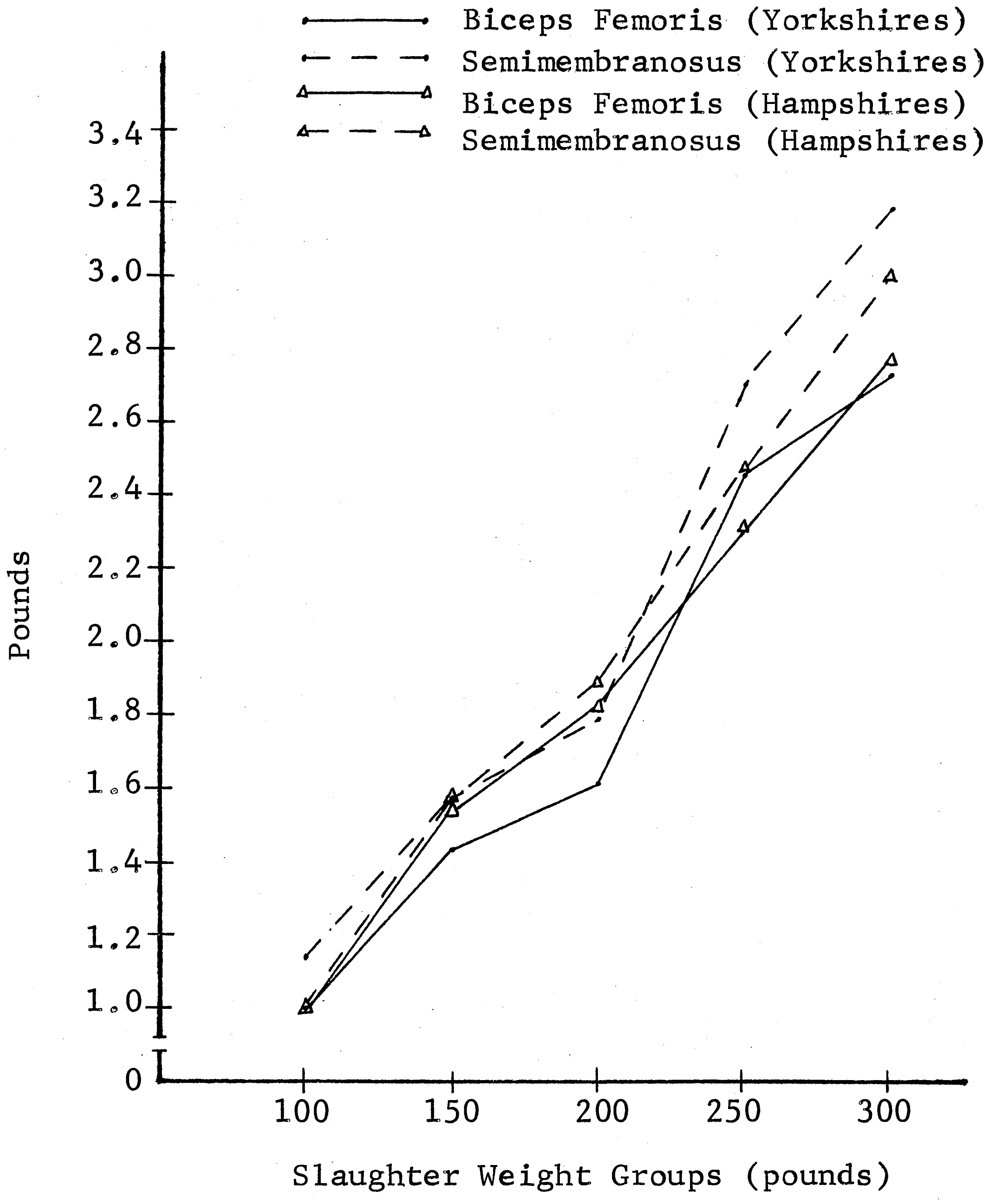

Figure 12. Mean Pounds of Fat-Free Lean for the Biceps Femoris and Semimembranosus Muscles for Yorkshires and Hampshires at Different Slaughter Weights.

slaughter weight. This rather uniform increase in pounds of fat-free lean for the two muscles was not prevalent in the Yorkshire data; however, significant non-linear responses were not found in the fat-free lean data (Appendix Table XXXVII). It is interesting to note that pounds of fat-free lean were generally greater for the semimembranosus muscles than fat-free lean for the biceps femoris muscles at each weight group for both breeds. These observed differences in fat-free lean weight were due primarily to the greater amounts of intermuscular and intramuscular fat found in the biceps femoris muscles as compared to the semimembranosus muscles.

Generally, fat-free lean for both muscles expressed as a percentage of carcass weight decreased as slaughter weight increased for each breed; however, the fat-free lean data for the semimembranosus muscle of the Yorkshires decreased from 100 to 200 pounds and then increased from 200 to 300 pounds slaughter weight (Table XVI). The statistical analysis of the fat-free lean data, expressed as a percentage of carcass weight, indicated that slaughter weight had a significant effect on fat-free lean for both muscles in the Hampshires and the biceps femoris in the Yorkshires (Appendix Tables XXXVII and XXXVIII). Rather weak linearlike responses were found for both muscles in the Hampshire data with very small decreases occurring in fat-free lean at each weight interval (except 150-200 pounds) for each 50 pound increase in slaughter weight.

The Association of Live and Carcass Measurements with Carcass Leanness in Pigs Slaughtered at Five Different Weights

Correlation coefficients were obtained between various live and carcass measures of leanness for five different weight groups of pigs. The statistical analyses of all variables were conducted on a breed basis; consequently, each weight group contained 14 Hampshires and 6 Yorkshires. Realizing the degree to which extreme values could affect correlation coefficients calculated from small numbers of observations, only general trends will be discussed, and conclusions will be drawn in a general manner. Correlation coefficients were determined by pooling the sums of squares within weight groups for the many traits studied. This procedure used to obtain correlation coefficients assumes that the estimation of the relationships between two traits are the same at each of the five different weight groups; however, this assumption may not be correct for every trait studied.

Live Measurements

Correlation Coefficients. Correlation coefficients for mean live K^{40} count and live backfat probe with several measures of leanness in the carcass are presented in Tables XVII and XVIII for Yorkshires and Hampshires, respectively. The correlation coefficients between K^{40} count and all measures of leanness for both breeds were significant

TABLE XVII

CORRELATION COEFFICIENTS BETWEEN LIVE ESTIMATES AND SEVERAL MEASURES OF LEANNESS IN YORKSHIRES PIGS[a]

	Live Estimates	
Measures of Leanness	Mean K^{40} Count	Mean Live Backfat Probe
Fat-free lean, lbs.	0.805**	-0.444*
Lean cuts, lbs.	0.838**	-0.445*
Ham, lbs.	0.741**	-0.556**
Ham and loin, lbs.	0.801**	-0.413*
Loin eye area, sq. in.	0.923**	-0.620**
Carcass backfat, in.	-0.663**	0.894**

* $P \leq .05$

** $P \leq .01$

[a] Correlation coefficients (pooled within weight groups) were calculated from data obtained from thirty animals.

TABLE XVIII

CORRELATION COEFFICIENTS BETWEEN LIVE ESTIMATES AND SEVERAL MEASURES OF LEANNESS IN HAMPSHIRE PIGS[a]

	Live Estimates	
Measures of Leanness	Mean K^{40} Count	Mean Live Backfat Probe
Fat-free lean, lbs.	0.596^{**}	-0.638^{**}
Lean cuts, lbs.	0.444^{**}	-0.516^{**}
Ham, lbs.	0.427^{**}	-0.552^{**}
Ham and loin, lbs.	0.406^{**}	-0.435^{**}
Loin eye area, sq. in.	0.473^{**}	-0.310^{**}
Carcass backfat, in.	-0.590^{**}	0.728^{**}

* $P \leq .05$

** $P \leq .01$

[a] Correlation coefficients (pooled within weight groups) were calculated from data obtained from seventy animals.

($P \leq .01$). The correlations between live estimates and measures of leanness computed from the Hampshires data (.596 to -0.590) appear to be lower than those from the Yorkshire data (.923 to -0.663). Since there were fewer Yorkshires, extreme values associated with the variables studied may have had a magnifying effect on those correlations from the Yorkshire data. The correlation coefficients between mean K^{40} count and pounds of fat-free lean were 0.805 for the Yorkshires and 0.596 for the Hampshires. These correlations indicate that there is some agreement between K^{40} count and pounds of fat-free lean, especially in the Yorkshires, and that the K^{40} counter is a reasonably reliable predictor of fat-free lean. Moser (1970) reported similar results with heavy hogs, where he obtained correlations of 0.85 and 0.84 between pounds of fat-free lean and K^{40} count of Yorkshire pigs weighing 250 and 300 pounds, respectively. Correlation coefficients between mean K^{40} count and pounds of lean cuts were 0.838 and 0.444 for the Yorkshires and Hampshires, respectively. Omtvedt et al. (1973) reported a correlation of 0.56 between the weight of lean cuts and the K^{40} estimate of lean cut yield in a study utilizing 190 barrows. Addison, Omtvedt, and Walters (1971) reported a correlation of 0.75 between live K^{40} count and weight of lean cuts.

The correlation coefficients for pounds of ham and ham and loin with live K^{40} count (within each breed) were similar and were found to be significant. The correlation coefficients for ham (0.741) and ham and loin (0.801) with

K^{40} count in the Yorkshires indicated a rather strong association between these two traits and K^{40} count. A very strong ($P \leq .01$) relationship was found between loin eye area and K^{40} count in the Yorkshires (0.923); however, the association was not as strong in the Hampshires (0.473). Further, carcass backfat was found to be significantly ($P \leq .01$) correlated with K^{40} count in both the Yorkshires (-0.663) and Hampshires (-0.590). These correlation coefficients are in agreement with Omtvedt et al. (1973).

Correlation coefficients between mean live backfat probe and carcass backfat were 0.894 and 0.728 for the Yorkshires and Hampshires, respectively, indicating that live backfat probe could predict carcass backfat with some degree of accuracy for both breeds. These correlation coefficients were slightly higher than those reported by Adams (1971), but were similar to those reported by Hazel and Kline (1959) and Pearson et al. (1957).

Significant correlation coefficients between live backfat probe and certain measures of leanness were found and are presented in Tables XVII and XVIII for Yorkshires and Hampshires, respectively. Live backfat probe accounted for 19.7 percent and 40.7 percent of the variation in pounds of fat-free lean and 17 percent and 19 percent of the variation in pounds of ham and loin for Yorkshires and Hampshires, respectively. Pearson et al. (1957) reported slightly higher correlations between live probe and measures of leanness, while Hazel and Kline (1959) and Adams (1971) found lower correlations than those established in this study.

In the Yorkshire data, the correlation coefficients between mean K^{40} count and certain measures of leanness were greater than those correlation coefficients associated with live probe, indicating that mean K^{40} count accounted for more variation in the leanness traits than did backfat probe (Table XVII). On the other hand, little difference occurred in the association between K^{40} count or live backfat probe with fat-free lean, lean cuts, ham, ham and loin, loin eye area, and carcass backfat for the Hampshire data (Table XVIII).

Prediction Equations. One of the primary objectives in this study involved the development of prediction equations for estimating pounds of fat-free lean in pigs, weighing between 100 and 300 pounds, with some degree of accuracy. Three live estimates were made on each pig prior to slaughter. These estimates were live weight, K^{40} count, and live backfat probe. A regression study was conducted on these estimates in an effort to determine their relationships with each other, as well as with fat-free lean and to establish some prediction equations which may be useful in estimating fat-free lean in pigs weighing between 100 and 300 pounds.

Linear prediction equations for fat-free lean are presented in Tables XIX and XX for Yorkshires and Hampshires, respectively. Standard errors of estimate and coefficients

TABLE XIX

LINEAR PREDICTION EQUATIONS FOR YORKSHIRES USING K^{40} COUNT, LIVE WEIGHT, AND LIVE BACKFAT PROBE[f]

Equation Number	Predicted Variable	B_o[a]	$B_{(weight)}$[b]	$B_{(count)}$[c]	$B_{(live\ probe)}$[d]	R^2	Standard Error of Estimate
1	FFL[e]	-106.443	+2.980(WT)			0.963	5.670
2	FFL	248.239		-0.204(CT)		0.913	8.705
3	FFL	234.518			-838.996(L.P.)	0.776	13.989
4	FFL	-19.975	+0.249(WT)	+0.0086(CT)		0.981	3.918
5	FFL	4.221	+0.425(WT)		-13.964(L.P.)	0.965	5.288
6	FFL	-17.079	+0.279(WT)	+0.0081(CT)	-6.153(L.P.)	0.982	3.910

[a] B_o = Regression coefficient, Y-intercept.

[b] Weight or WT = Live weight (pounds).

[c] Count or CT = K^{40} counts per minute.

[d] Live probe or L.P. = Live backfat probe (inches).

[e] FFL = $\hat{Y}_{FFL}$ = Predicted pounds of fat-free lean.

[f] Linear prediction equations were established from live measurements taken on thirty animals.

TABLE XX

LINEAR PREDICTION EQUATIONS FOR HAMPSHIRES USING K^{40} COUNT, LIVE WEIGHT, AND LIVE BACKFAT PROBE[f]

Equation Number	Predicted Variable	B_o[a]	$B_{(weight)}$[b]	$B_{(count)}$[c]	$B_{(live\ probe)}$[d]	R^2	Standard Error of Estimate
1	FFL[e]	-138.801	+3.718(WT)			0.944	5.548
2	FFL	-568.121		+0.486(CT)		0.874	8.325
3	FFL	50.462			-141.566(L.P.)	0.779	11.041
4	FFL	-12.538	+0.219(WT)	+0.0077(CT)		0.963	4.462
5	FFL	13.068	+0.388(WT)		-18.287(L.P.)	0.945	5.407
6	FFL	-9.302	+0.256(WT)	+0.0071(CT)	-7.082(L.P.)	0.964	4.435

[a] B_o = Regression coefficient, Y-intercept.

[b] Weight or WT = Live weight (pounds).

[c] Count or CT = K^{40} counts per minute.

[d] Live probe or L.P. = Live backfat probe (inches).

[e] FFL = $\hat{Y}_{FFL}$ = Predicted pounds of fat-free lean.

[f] Linear prediction equations were established from live measurements taken on seventy animals.

of determination are also given for each regression equation. The standard error of estimate is the standard deviation of the dependent variable when the independent variable (or variables) is held constant. Coefficients of determination estimate the proportion of the total variation of the dependent variable (fat-free lean) that can be attributed to its linear regression on the independent variable or variables. It must be emphasized that the prediction equations were determined across weight groups.

The value of an instrument such as the K^{40} whole-body counter or Duncan Lean Meter, depends upon its ability to improve the accuracy with which we make predictions. Results of this study indicated that weight alone removed 96.3 percent of the variation when predicting fat-free lean in the Yorkshires and 94.4 percent of the variation in the Hampshires. When K^{40} count was placed in a regression equation, 91.3 percent of the variation in predicting fat-free lean was accounted for in the Yorkshires, while the value was 87.4 percent in the Hampshires. The live probe estimate contributed the least insofar as removing variation in estimating fat-free lean (77.6 percent in the Yorkshires and 77.9 percent in the Hampshires).

It appears from these data obtained from a population of very muscular pigs that live weight has the most value in predicting fat-free lean when used as the only independent variable in a regression equation. These results are not in agreement with those reported by Addison _et al_. (1972).

These researchers found that when slaughter weight was combined with K^{40} count in a regression equation, neither the amount of variation accounted for nor the standard error of estimate were changed dramatically. When weight was added to K^{40} count in a regression equation for predicting fat-free lean in this study, a 15 percent increase in variation accounted for a reduction of 3 pounds in standard errors of estimate were realized for both breeds. The standard error of estimate reported by Addison and coworkers (1972) for predicting fat-free lean using weight as the independent variable was 2.5 pounds smaller than the standard error of estimate for the corresponding regression equation in this study.

The composition variation in the pigs used in these studies was quite different which may partially explain the lack of agreement between the results of the two studies. Compositional differences were quite narrow between the Hampshires and Yorkshires at approximately 220 pounds while a much greater variation was recognized in the pigs used by Addison and coworkers (1972). Pounds of fat-free lean is such an example with a range of 65 to 92 pounds recognized in 155 hogs by Addison _et_ _al_. (1972) while a range of approximately 77 to 88 pounds for fat-free lean was observed in the Hampshires and Yorkshires from 200 to 250 pounds live weight.

Different combinations of the three live animal estimates were used in several prediction equations and coefficients of determination and standard errors of estimate for each equation were carefully evaluated. Prediction equations (number) 4 and 6 listed in Tables XIX and XX were superior to all other equations studied in that they had smaller standard errors of estimate and accounted for a larger amount of the variation in predicting fat-free lean. The regression equation composed of all three estimates (in the sequence presented in equation number 6 for each breed) accounted for the most variation in predicting pounds of fat-free lean (96.4 percent for Hampshires and 98.2 percent for Yorkshires) and had the smallest standard error of estimate (4.435 and 3.910 for Hampshires and Yorkshires, respectively). However, its advantage over using live weight and K^{40} count in a regression equation appears to be quite small.

K^{40} count, when added to weight in a prediction equation, improved the estimate of fat-free lean. The coefficient of determination was increased by 2 percent and the average standard error of estimate was reduced by 0.9 of a pound of fat-free lean in the Hampshires and 1.7 pounds in the Yorkshires. The small increase in coefficients of determination and the small decrease in standard errors of estimate cause one to question the value of using the K^{40} counter to predict fat-free lean in very muscular, growthy pigs. The increased precision obtained when adding K^{40} count to the prediction equation involving only live weight in very muscular hogs appears to be of little value.

A segment of this research involved the evaluation of the K^{40} counter as an instrument for estimating pounds of fat-free lean in pigs at five different weights. Linear prediction equations (where live weight and K^{40} count were the independent variables) were developed for each weight and are presented in Tables XXI and XXII for Yorkshires and Hampshires, respectively.

It is interesting to note that the regression equations developed for the 250 pound weight groups for both breeds had the largest coefficients of determination. The regression equation for 250 pound Yorkshires accounted for 81 percent of the variation in estimating fat-free lean, while the regression equation for the 250 pound Hampshires accounted for 46 percent of the variation in pounds of fat-free lean.

A large amount of variation appears to be associated with the individual regression equations for each breed since the coefficients of B_o, $B_{(weight)}$, and $B_{(count)}$ vary in both sign and magnitude from one weight group to the next. Two factors have contributed to this variation between the regression equations, as well as the low coefficients of determination of the prediction equations listed in Tables XXI and XXII. First, since the data were analyzed on a breed basis, each slaughter weight group consisted of 14 Hampshires and 6 Yorkshires. Consequently, too few numbers were available to obtain regression equations that would be expected to be precise in estimating fat-free lean

TABLE XXI

LINEAR PREDICTION EQUATIONS FOR YORKSHIRES USING LIVE WEIGHT AND K^{40} COUNT AT DIFFERENT SLAUGHTER WEIGHTS

Slaughter Weight[a]	Predicted Variable	B_o[b]	$B_{(weight)}$[c]	$B_{(count)}$[d]	R^2	Standard Error of Estimate
100	FFL[e]	-38.663	+0.418(WT)	+0.009(CT)	0.632	3.619
150	FFL	29.128	-0.129(WT)	+0.010(CT)	0.486	4.844
200	FFL	81.079	-0.165(WT)	+0.005(CT)	0.613	1.487
250	FFL	-85.360	+0.187(WT)	+0.022(CT)	0.901	5.367
300	FFL	-154.498	+0.737(WT)	+0.007(CT)	0.574	5.430

[a] Six animals in each weight group.

[b] B_o = Regression coefficient, Y-intercept.

[c] Weight or WT = Live weight (pounds).

[d] Count or CT = K^{40} counts per minute.

[e] FFL = $\hat{Y}_{FFL}$ = Predicted pounds of fat-free lean.

TABLE XXII

LINEAR PREDICTION EQUATIONS FOR HAMPSHIRES USING LIVE WEIGHT AND K^{40} COUNT AT DIFFERENT SLAUGHTER WEIGHTS

Slaughter Weight[a]	Predicted Variable	B_o[b]	$B_{(weight)}$[c]	$B_{(count)}$[d]	R^2	Standard Error of Estimate
100	FFL[e]	-30.738	+0.234(WT)	+0.012(CT)	0.543	2.643
150	FFL	15.822	+0.145(WT)	+0.004(CT)	0.220	4.796
200	FFL	55.573	-0.167(WT)	+0.009(CT)	0.372	4.429
250	FFL	-140.299	+0.705(WT)	+0.009(CT)	0.680	4.175
300	FFL	16.898	+0.101(WT)	+0.009(CT)	0.209	7.508

[a] Fourteen animals in each weight group.

[b] B_o = Regression coefficient, Y-intercept.

[c] Weight or WT = Live weight (pounds).

[d] Count or CT = K^{40} counts per minute.

[e] FFL = $\hat{Y}_{FFL}$ = Predicted pounds of fat-free lean.

for each of five weights for both breeds. The uniform composition of the pigs in the study may have also contributed to the variation among the prediction equations at the different weights. The superior muscling and trimness characteristics of the Hampshires and especially the Yorkshires have been eluded to and discussed in detail. For example, all but two hogs in the study were found to be U.S.D.A. No. 1 grade hogs. This is a much higher percentage of U.S.D.A. No. 1's than would be found in a random assortment of pigs presently found in the swine industry. Because of the uniformity of composition of the pigs within each weight group for both breeds, the K^{40} counter was not capable of accurately monitoring the very small differences in composition in this population. If larger numbers of pigs having greater compositional variation had been used in this study, the prediction equations developed to predict fat-free lean at five different weights would probably have been more comparable in estimating fat-free lean. Another possible reason for large differences in coefficients of determination in the lighter weight pigs evolves from the fact that those pigs weighing 100 and 150 pounds could have possibly sat down in the counting chamber while being K^{40} evaluated. A metal bar was used to prevent such an activity while K^{40} counting the heavier pigs; however, it was very difficult to position the smaller pigs on the metal bar and was therefore not used. If the pigs did sit down while being counted, their net K^{40} counts would be reduced since the distance of the animal from the detectors would have been greater and the likelihood of some of the emitted gamma rays never reaching the detectors would have been increased.

Carcass Measurements

Correlation Coefficients. Much of the literature concerning the relationship between weights of muscles and weight of separable lean of the carcass has been done with beef. Butterfield (1965), in a study involving 35 steers, reported correlations of 0.98 and 0.97 between weights of the biceps femoris and semimembranosus, respectively, and separable muscle weight of the carcass. Orme et al. (1960) reported correlation coefficients of 0.96 and 0.92 between biceps femoris weight and semimembranosus plus adductor weight with carcass lean, respectively, in 43 mature Hereford cows. McMeekan (1941), in a pork study, found a correlation coefficient of 0.814 between psoas weight and total muscle. He also reported a correlation of 0.971 between total muscle weight of the leg and total muscle weight of the carcass. With associations between muscle weights and total carcass lean as strong as those reported by the previously mentioned researchers, it appears that the weight of a single muscle could, perhaps, be used to rather accurately estimate the total lean in a carcass without complete dissection; thereby, conserving both time and the expense of such a procedure.

Correlation coefficients between the weights of the biceps femoris and semimembranosus and several carcass measurements are presented in Tables XXIII and XXIV for Yorkshires and Hampshires, respectively. As previously mentioned, all correlation coefficients for the traits in question were calculated by pooling the sums of squares within weight groups. It appears that the relationships between the two individual muscle weights and fat-free lean, lean cuts, loin eye area, and carcass backfat, even though significant in most cases, were not very strong and, therefore, would account for only a small amount of the variation associated with each of the traits. The biceps femoris weight was found to be significantly correlated with fat-free lean and lean cuts and accounted for 26 percent and 24 percent of the variation, respectively, for the two measures of leanness in the Yorkshires. Slightly stronger relationships were found between biceps femoris and semimembranosus muscle weights and fat-free lean and lean cuts when the two traits were expressed as a percentage of slaughter weight for both breeds. Correlation coefficients between the two muscle weights and loin eye area (0.292 and 0.395) were significant ($P \leq .01$), but only 8.8 and 15.9 percent of the variation associated with loin eye area in the Hampshires were accounted for by the two muscle weights. Similar results were found in the Yorkshire data. Non-significant negative relationships were found between carcass backfat and the two muscle weights for both breeds.

TABLE XXIII

CORRELATION COEFFICIENTS BETWEEN BICEPS FEMORIS AND SEMIMEMBRANOSUS WEIGHTS AND VARIOUS CARCASS MEASUREMENTS IN YORKSHIRE PIGS[a]

Carcass Measurements	Weight (pounds)	
	Biceps Femoris	Semimembranosus
Fat-free lean, lbs.	0.509**	0.486**
Lean cuts, lbs.	0.492**	0.508**
Fat-free lean, percent slaughter wt., lbs.	0.621**	0.592**
Lean cuts, percent slaughter wt., lbs.	0.580**	0.613**
Loin eye area, sq. in.	0.388*	0.305
Carcass backfat, in.	-0.005	-0.032

* $P \leq .05$

** $P \leq .01$

[a] Correlation coefficients determined from data obtained from twenty animals, pooled on a within weight group basis.

TABLE XXIV

CORRELATION COEFFICIENTS BETWEEN BICEPS FEMORIS AND SEMIMEMBRANOSUS WEIGHTS AND VARIOUS CARCASS MEASUREMENTS IN HAMPSHIRE PIGS[a]

Carcass Measurements	Weight (pounds)	
	Biceps Femoris	Semimembranosus
Fat-free lean, lbs.	0.301*	0.333**
Lean cuts, lbs.	0.303*	0.381**
Fat-free lean, percent slaughter wt., lbs.	0.403**	0.461**
Lean cuts, percent slaughter wt., lbs.	0.408**	0.488**
Loin eye area, sq. in.	0.292*	0.395**
Carcass backfat, in.	-0.134	-0.208

* $P \leq .05$

** $P \leq .01$

[a] Correlation coefficients determined from data obtained from sixty animals, pooled on a within weight group basis.

It appears from the data presented in Tables XXIII and XXIV that neither biceps femoris nor semimembranosus weights have strong enough relationships to serve as reliable predictors of such carcass parameters as fat-free lean, lean cuts, loin eye area, and carcass backfat in pigs with superior muscling similar to those used in this study.

Prediction Equations. A regression study was conducted on the weights of the biceps femoris and semimembranosus muscles in an effort to establish some prediction equations that may be useful in estimating fat-free lean in pigs across the weight groups 100, 150, 200, 250, and 300 pounds. Linear prediction equations for fat-free lean are presented in Tables XXV and XXVI for both breeds. Standard errors of estimate and coefficients of determination are also presented for each regression equation. Results of these studies indicate that biceps femoris weight alone removed 86.3 percent of the variation when predicting fat-free lean in the Yorkshires, while 90.2 percent of the variation in the Hampshires was removed. Prediction equations containing only semimembranosus weight accounted for 86.8 percent and 91.6 percent of the variation in fat-free lean in Yorkshires and Hampshires, respectively. Coefficients of determination were increased and standard errors of estimate decreased when both muscle weights were used to predict fat-free lean. The greatest improvement in predicting fat-free lean in both breeds occurred between the biceps femoris weight equation and the prediction equation using both muscle weights. A

TABLE XXV

LINEAR PREDICTION EQUATIONS FOR YORKSHIRES USING BICEPS FEMORIS AND SEMIMEMBRANOSUS WEIGHTS[a]

Predicted Variable	B_o[b]	B_{BF}[c]	B_{SM}[d]	R^2	Standard Error of Estimate
FFL[e]	11.334	+27.464(BF)		0.863	8.514
FFL	9.769		+30.818(SM)	0.868	8.362
FFL	9.291	+13.057(BF)	+16.783(SM)	0.883	7.939

[a] Linear prediction equations were established from muscle weight data obtained from twenty animals.

[b] B_o = Regression coefficient, Y-intercept.

[c] B_{BF} = Biceps femoris weight, lb.

[d] B_{SM} = Semimembranosus weight, lb.

[e] FFL = $\hat{Y}_{FFL}$ = Predicted pounds of fat-free lean.

TABLE XXVI

LINEAR PREDICTION EQUATIONS FOR HAMPSHIRES USING BICEPS FEMORIS AND SEMIMEMBRANOSUS WEIGHTS[a]

Predicted Variable	B_o[b]	B_{BF}[c]	B_{SM}[d]	R^2	Standard Error of Estimate
FFL[e]	5.218	+31.841(BF)		0.902	9.320
FFL	4.558		+36.965(SM)	0.916	8.603
FFL	3.633	+12.613(BF)	+22.946(SM)	0.926	8.322

[a] Linear prediction equations were established from muscle weight data obtained from sixty animals.

[b] B_o = Regression coefficient, Y-intercept.

[c] B_{BF} = Biceps femoris weight, lb.

[d] B_{SM} = Semimembranosus weight, lb.

[e] FFL = $\hat{Y}_{FFL}$ = Predicted pounds of fat-free lean.

2.0 and 2.4 percent increase in the removal of variation in fat-free lean and a decrease in the standard error of estimate of 0.575 and 0.998 pounds were realized in the Hampshires and Yorkshires, respectively.

In comparing the values in Tables XIX and XX with those in Tables XXV and XXVI, the prediction equations composed of live animal estimates were superior in predicting fat-free lean than those using muscle weights. Coefficients of determination were increased up to 10 percent and standard errors of estimate reduced up to 4 pounds when predicting fat-free lean from equations containing live weight and K^{40} count as compared to the equations based on the two muscle weights. After considering the results of both regression studies (live estimates and muscle weights), predicting fat-free lean from the equation based on live weight alone may have the most practical application.

Relationships Between Various Carcass Measurements and Fat-Free Lean and Lean Cuts

Since there is limited data in the literature on the relationships between various carcass measurements and accurately determined fat-free lean, correlations between fat-free lean and pounds of lean cuts, ham, ham and loin, loin eye area, backfat and mg of potassium were determined and are presented in Tables XXVII and XXVIII for Yorkshires and Hampshires, respectively. As previously mentioned, the correlation coefficients were determined by pooling the sums

TABLE XXVII

CORRELATION COEFFICIENTS BETWEEN VARIOUS CARCASS MEASUREMENTS AND FAT-FREE LEAN EXPRESSED AS POUNDS AND PERCENT IN YORKSHIRE PIGS[a]

Carcass Measurements	Pounds[b]	Percent[c]
Lean cuts, lbs.	0.974**	0.875**
Ham, percent slaughter weight	0.544**	0.504**
Ham and loin, percent slaughter weight	0.552**	0.606**
Lean cuts, percent slaughter weight	0.959**	0.967**
Loin eye area, sq. in.	0.689**	0.476**
Backfat, in.	-0.483**	-0.473**
Potassium, mg/g of ground separable lean (fat-free, dry matter basis)	-0.038	-0.111

[a] Correlation coefficients determined from data obtained from thirty animals.

[b] Fat-free lean, lbs.

[c] Fat-free lean, percent slaughter weight (24-hour shrink).

* $P \leq .05$

** $P \leq .01$

TABLE XXVIII

CORRELATION COEFFICIENTS BETWEEN VARIOUS CARCASS MEASUREMENTS AND FAT-FREE LEAN EXPRESSED AS POUNDS AND PERCENT IN HAMPSHIRE PIGS[a]

Carcass Measurements	Pounds[b]	Percent[c]
Lean cuts, lbs.	0.952**	0.842**
Ham, percent slaughter weight	0.780**	0.737**
Ham and loin, percent slaughter weight	0.734**	0.703**
Lean cuts, percent slaughter weight	0.890**	0.926**
Loin eye area, sq. in.	0.451**	0.488**
Backfat, in.	-0.597**	-0.681**
Potassium, mg/g of ground separable lean (fat-free, dry matter basis)	0.084	0.224

[a] Correlation coefficients determined from data obtained from seventy animals.

[b] Fat-free lean, lbs.

[c] Fat-free lean, percent slaughter weight (24-hour shrink).

* $P \leq .05$

* $P \leq .01$

of squares within weight groups of the traits in question. The correlation coefficients between pounds of fat-free lean and pounds of lean cuts were found to be highly significant (0.974 and 0.952) and would account for 94.9 and 90.6 percent of the variation in estimating fat-free lean in Yorkshires and Hampshires, respectively. When lean cuts were expressed as a percentage of slaughter weight, a weaker association between fat-free lean and lean cuts was observed, with correlation coefficients of 0.875 and 0.842 for the Yorkshires and Hampshires, respectively. These results point to a close agreement between fat-free lean and lean cuts expressed as a percentage of slaughter weight and is expected since the major difference between the variables is intramuscular fat. The association between fat-free lean and lean cuts may have been enhanced since the ether-extract values for both breeds were lower than most reported in the literature for swine.

Correlations ($P \leq .01$) between pounds of fat-free lean and percent ham and percent ham and loin were 0.544 and 0.552, respectively, for the Hampshires and 0.780 and 0.734, respectively, for the Yorkshires, while correlation coefficients between pounds of fat-free lean and carcass backfat were -0.483 for the Yorkshires and -0.597 for the Hampshires. Of these parameters, lean cuts expressed as a percent of slaughter weight appeared to have the greatest potential for predicting fat-free lean with correlations between pounds of lean cuts (expressed as percent of slaughter weight) and pounds of fat-free lean of 0.959 and 0.890 for Yorkshires and Hampshires, respectively. Thus, 92 percent of the variation associated with predicting pounds of fat-free lean in Yorkshires similar to those used in this study would be removed by using the variable, percent lean cuts. The relationships between fat-free lean (pounds or percent) and mg of potassium per g of ground separable lean (fat-free, dry matter basis) were non-significant for both breeds. However, the correlation coefficient between fat-free lean, expressed as a percent of slaughter weight, and potassium approached significance at the five percent level in the Hampshires. Digestion and technique errors associated with the chemical determinations of potassium, as well as a small number of observations, especially in the Yorkshires, may have contributed to the low correlations found between chemical potassium and fat-free lean. These results are not in agreement with Kirton and Pearson (1963), Martin *et al.* (1963), and Stant (1963) who reported significant positive relationships between chemically determined potassium and measures of leanness.

Tables XXIX and XXX present correlation coefficients between various carcass measurements and lean cuts expressed as pounds and as a percentage of slaughter weight for Yorkshires and Hampshires. Correlation coefficients ($P \leq .01$) between pounds of lean cuts and percent ham were 0.605 and 0.768 for the Yorkshires and Hampshires; while the correlations between pounds of lean cuts and percent ham and loin

TABLE XXIX

CORRELATION COEFFICIENTS BETWEEN VARIOUS CARCASS MEASUREMENTS AND LEAN CUTS EXPRESSED AS POUNDS AND PERCENT IN YORKSHIRE PIGS[a]

Carcass Measurements	Pounds[b]	Percent[c]
Ham, percent slaughter weight	0.605**	0.590**
Ham and loin, percent slaughter weight	0.542**	0.630**
Loin eye area, sq. in.	0.768**	0.575**
Backfat, in.	-0.415*	-0.423*
Potassium, mg/g of ground separable lean (fat-free, dry matter basis)	-0.100	-0.186

[a] Correlation coefficients determined from data obtained from thirty animals.

[b] Lean cuts, lbs.

[c] Lean cuts, percent slaughter weight (24-hour shrink).

* $P \leq .05$

** $P \leq .01$

TABLE XXX

CORRELATION COEFFICIENTS BETWEEN VARIOUS CARCASS MEASUREMENTS AND LEAN CUTS EXPRESSED AS POUNDS AND PERCENT IN HAMPSHIRE PIGS[a]

Carcass Measurements	Pounds[b]	Percent[c]
Ham, percent slaughter weight	0.768**	0.774**
Ham and loin, percent slaughter weight	0.730**	0.701**
Loin eye area, sq. in.	0.328**	0.376**
Backfat, in.	-0.503**	-0.594**
Potassium, mg/g of ground separable lean (fat-free, dry matter basis)	-0.004	0.161

[a] Correlation coefficients determined from data obtained from seventy animals.

[b] Lean cuts, lbs.

[c] Lean cuts, percent slaughter weight (24-hour shrink).

* $P \leq .05$

** $P \leq .01$

were 0.542 for the Yorkshires and 0.730 for the Hampshires. These results indicate a rather close relationship, especially in the Hampshires, between lean cuts and percent ham and percent ham and loin. This is as expected since ham and loin are major components of the quantity "lean cuts."

Loin eye area was found to be significantly ($P \leq .01$) correlated with lean cuts (when expressed as pounds or percent) in both breeds, and accounted for 76.8 percent of the variation in pounds of lean cuts of the Yorkshires and 32.8 percent in the Hampshires. The relationships between lean cuts and the various carcass measurements listed in Tables XXIX and XXX were very similar to those reported by Omtvedt et al. (1967), Arganosa (1968), and Lasley et al. (1956).

Backfat was also significantly ($P \leq .05$) correlated with pounds and percent lean cuts, with correlation coefficients of -0.415 and -0.423, respectively, for the Yorkshires and -0.503 and -0.594, respectively, for the Hampshires. The correlation coefficients were very similar to those reported by Adams (1971), Moser (1970), and Lasley et al. (1956).

The association between the potassium concentration of separable lean and lean cuts (expressed as pounds or percent) were non-significant for both breeds, as in the case with fat-free lean.

The Chemical Composition of Separable Lean and of Specific Muscles from Pigs Slaughtered at Five Different Weights

In order for chemical analyses in carcass composition studies to be meaningful, sampling and technique errors of the different chemical procedures must be known. The sampling procedures used to obtain the ground lean samples (that were chemically analyzed for ether-extract, moisture, and potassium content) are described in detail in the Materials and Methods Section.

Chemical Composition of Separable Lean

The amounts of variation accounted for in percent ether-extract for the sampling procedure of the separable lean used in this study are presented in Appendix Tables LIII and LIV for the Yorkshires and Hampshires, respectively. "Animal" accounted for the greatest amount of variation in percent ether-extract for both breeds. The percent variation accounted for by animals ranged from 95.08 to 99.75 in the Yorkshires and from 98.39 to 99.75 in the Hampshires. Determination accounted for the least amount of variation in the Yorkshires (0.04-1.63 percent), while grab accounted for the least amount in the Hampshires (0.18-1.20 percent). The percent variation accounted for by both grab and determination was quite small for any of the weight groups for either breed when compared to the percent variation accounted for by animal. In addition, the variation accounted for by grab and determination was rather uniform for all weight groups for both breeds. These observations indicate that the sampling procedure used in this study was very adequate in an effort to obtain a representative sample of lean for conducting ether-extract analyses. In fact, it may not be necessary to collect three grab samples when sampling the ground separable lean of a pork carcass to obtain a representative sample if the sampling procedure was identical to the one used in this study. The percent variation accounted for by grab and determination were considerably lower than those reported by Moser (1970) and Munson *et al*. (1966).

The coefficient of variation for the duplicates of ether-extract were 1.28 percent for those samples from 100 pound pigs; 1.31 percent for the 150 pound pigs; 1.45 percent for the 200 pound pigs; 1.13 percent for the 250 pound pigs; and 1.15 percent for the samples from the 300 pound pigs. These coefficients of variation indicate that the sampling procedure and technique were quite adequate for obtaining accurate results.

The chemical analyses for ether-extract, moisture, and potassium of ground separable lean are presented in Table XXXI for Yorkshires and Hampshires.

Slaughter weight was found to have a significant ($P \leq .01$) effect on percent ether-extract in the ground separable lean of the Hampshires; on the other hand, no significant effect was found for percent ether-extract for

TABLE XXXI

MEANS AND STANDARD ERRORS FOR CHEMICAL COMPONENTS OF THE SEPARABLE LEAN FOR YORKSHIRE AND HAMPSHIRE PIGS SLAUGHTERED AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Yorkshires, 6/wt. group					
Ether-extract, percent	10.72±0.97	13.21±1.66	12.43±0.54	12.99±0.70	13.09±0.98
Moisture, percent	69.92±0.87	67.74±1.47	67.51±0.49	67.02±0.68	66.43±0.82
Potassium[a]	14.01±0.18	13.91±0.69	14.51±0.27	14.14±0.40	14.06±0.21
Hampshires, 14/wt. group					
Ether-extract, percent	11.91±0.74	13.08±0.57	14.84±0.59	16.22±0.60	15.77±0.42
Moisture, percent	69.01±0.61	67.41±0.38	66.02±0.44	64.82±0.47	65.21±0.27
Potassium[a]	15.33±0.38	15.39±0.13	15.62±0.19	15.58±0.22	15.06±0.13

[a] Determined by atomic absorption spectrophotometry and expressed as mg of potassium per g of ground lean sample (fat-free, dry matter basis).

the Yorkshire lean (Appendix Tables XXXIX and XL). The response curve for percent ether-extract in the Hampshire ground separable lean (illustrated in Figure 13) suggests a linear relationship between slaughter weight and percent ether-extract from 100 to 250 pounds. In fact, increases of 1.17, 1.76, and 1.38 percent ether-extract were found for each 50 pound increase in slaughter weight up to 250 pounds. A non-linear response ($P \leq .05$) was found in the data and accounted for 12.0 percent of the total sums of squares for percent ether-extract. This non-linear response was due to a lack of increased percent ether-extract with a corresponding increase in slaughter weight (250 to 300 pounds). This observation is further illustrated in Figure 13 where the response curve levels off from 250 to 300 pounds slaughter weight.

As shown in Figure 13, there was a slight increase in percent ether-extract in the Yorkshire lean from 100 to 150 pounds; but then the response curve leveled off and there was very little increase in percent ether-extract with increased slaughter weight. This trend was responsible for the non-significant effect of slaughter weight on percent ether-extract for the Yorkshire lean. The Yorkshires appeared to have deposited less intramuscular fat than the Hampshires with increased slaughter weight.

The coefficient of variation for the duplicates of the moisture determinations were 0.98 percent for those samples from 100 pound pigs; 1.02 percent for the 150 pound pigs;

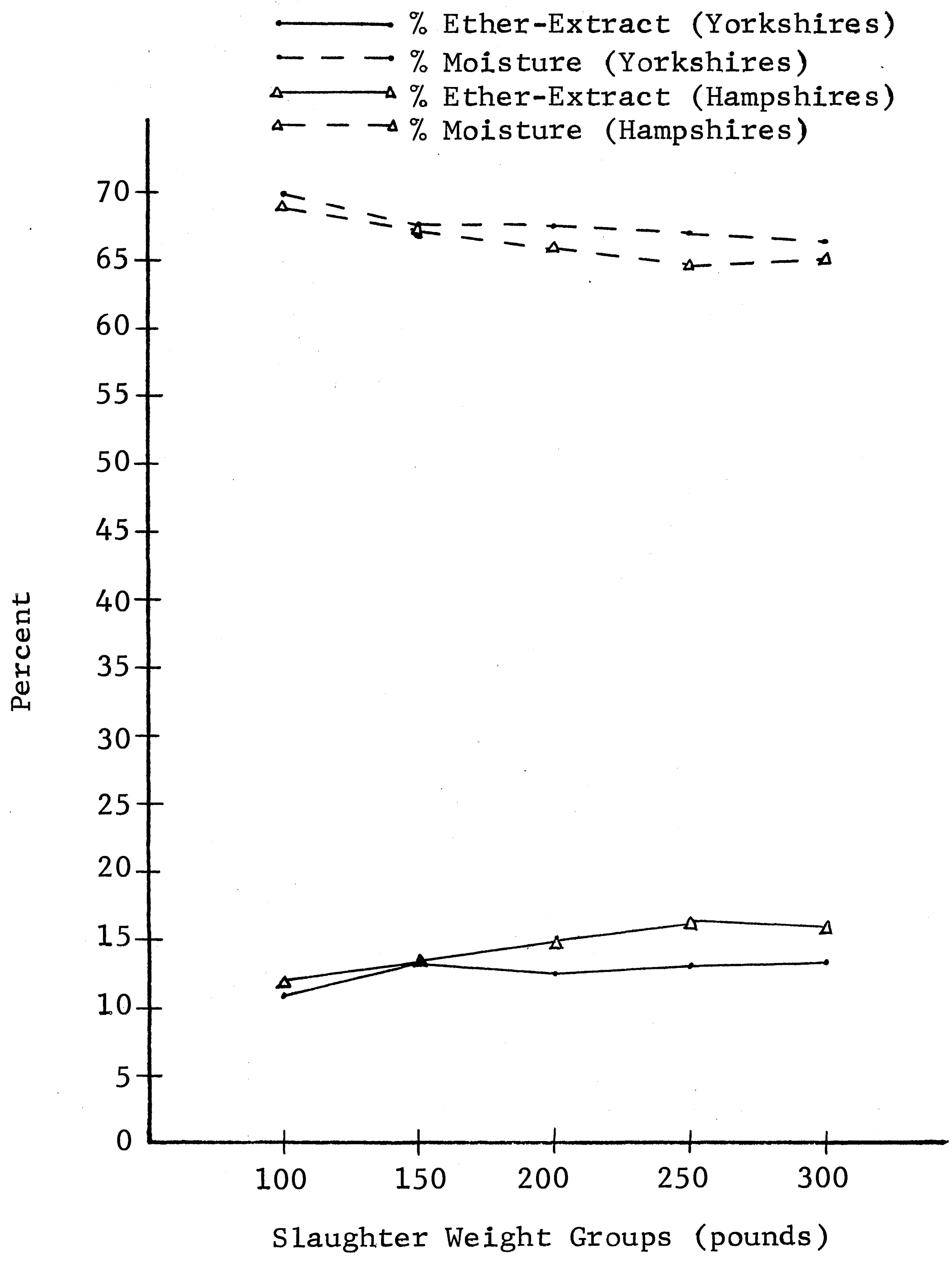

Figure 13. Means for Percent Ether-Extract and Percent Moisture in the Separable Lean for Yorkshire and Hampshire Pigs Slaughtered at Different Weights.

0.96 percent for the 200 pound pigs; 0.93 percent for the 250 pound pigs; and 0.92 percent for the samples from the 300 pound pigs. These low coefficient of variation values indicate that the techniques used to obtain percent moisture were quite adequate to establish accurate results.

Slaughter weight was found to have a significant effect on percent moisture for both Yorkshire and Hampshire ground separable lean. As slaughter weight increased, percent moisture decreased as illustrated in Figure 13. A linear trend was observed from 150 to 300 pounds for the response curve of the Yorkshires with decreases of 0.23, 0.49, and 0.59 percent for 150-200, 200-250, and 250-300 pound weight intervals, respectively.

A decrease in percent moisture was found from 100 to 250 pounds slaughter weight in the Hampshire data with a slight increase observed from 250 to 300 pounds. A significant ($P \leq .05$) non-linear response was found in the Hampshire data and was primarily due to the small increase in percent moisture observed from 250 to 300 pounds slaughter weight.

The decrease in percent moisture with increased slaughter weight for both breeds was expected since a reciprocal relationship is generally observed between percent moisture and percent ether-extract. Percent moisture was found to be greater at each slaughter weight in the Yorkshire data when compared to the Hampshire data. This was to be expected since the Yorkshire separable lean contained less ether-extract than that of the Hampshires at each slaughter weight.

The amounts of variation accounted for by the sampling procedure when determining the potassium content in separable lean are presented in Appendix Tables LV and LVI for Yorkshires and Hampshires, respectively. One would expect that animal differences would account for most of the variation in the potassium concentration of separable lean; however, this was not the case for either breed. The amount of variation accounted for by animal for the different weight groups ranged from 89.74 percent to 4.30 percent for the Yorkshires and from 66.78 percent to 12.27 percent for the Hampshires.

In most cases for both breeds, determination differences accounted for the greatest amount of variation. If the sampling procedure for the separable lean had been adequate (as in the case for percent ether-extract), one would expect small amounts of variation to be accounted for by the sampling procedure, and the variation would be relatively uniform between weight groups. Such was not the case for determining the potassium content in separable lean in this study. Since determination differences accounted for a considerable amount of the variation in potassium concentration, it appears that a large majority of the variation in potassium was introduced in the laboratory. The potassium determinations were conducted by an experienced technician in the Soils Laboratory; consequently, the large determination errors for both breeds appear to have a large equipment-technique error associated with them. A portion of the erratic results obtained may also be due to chance since the degrees of freedom were quite small for animal (3 and 7 for Yorkshires and Hampshires, respectively). In addition, poor technique used when preparing the samples for chemical potassium analyses may have caused inaccurate estimates of potassium in the lean, thereby possibly increasing the variation accounted for by differences in determination duplicates.

Similar potassium analysis results were reported by McLellan (1970) who also found differences in determination accounting for a large portion of the variation in percent potassium. The coefficients of variation for the mean of potassium duplicates of separable lean averaged 5.03 percent and ranged from 4.36 to 6.82 percent. The coefficients of variation obtained in this study were considerably smaller than the coefficients of variation of 9.6 percent reported by Lohman, Dieter, and Norton (1970) and the coefficients of variation of 11.1 percent reported by Johnson, Walters, and Whiteman (1972).

Slaughter weight was found to have no significant relationship to potassium concentration of separable lean for either breed. Very little change was observed in the potassium concentration of separable lean for either breed as weight increased from 100 to 300 pounds. The potassium concentration ranged from 14.01 to 14.06 mg of potassium per g of ground lean sample (fat-free, dry matter basis) in 100 to 300 pound Yorkshires and 15.33 to 15.06 mg of potassium in 100 to 300 pound Hampshires. These trends are more clearly illustrated in Figure 14. These results are not in agreement with those of other researchers who have reported a decreasing trend in the potassium concentration of lean with increase in weight or age (Forbes, 1955; Holliday et al., 1957; Anderson and Langham, 1959). On the other hand, Widdowson and Dickerson (1964) reported that in rats the potassium concentration rises rapidly in the fat-free body during the first 30 days and then remains at the same level for at least 320 days. Spray and Widdowson (1950) presented evidence obtained from several species indicating that the potassium concentration in the fat-free body rapidly increases from four to ten weeks after birth, and then levels off. It is apparent from Figure 14 that no dramatic increases or decreases in potassium concentration occurred as the pigs increased in age and weight. These results correspond with those of Spray and Widdowson (1950) who studied 16 hogs slaughtered at 0, 21, 56, 112, 168, and 259 days of age.

A breed difference was also apparent in regard to the potassium concentration of the separable lean with the Hampshires possessing at least 1.0 or more mg of potassium at each weight group than the Yorkshires. This observation is in agreement with Gillett, Pearson, and Kirton (1965) who reported that lean from Hampshires contained significantly more potassium than Yorkshires on a per unit basis.

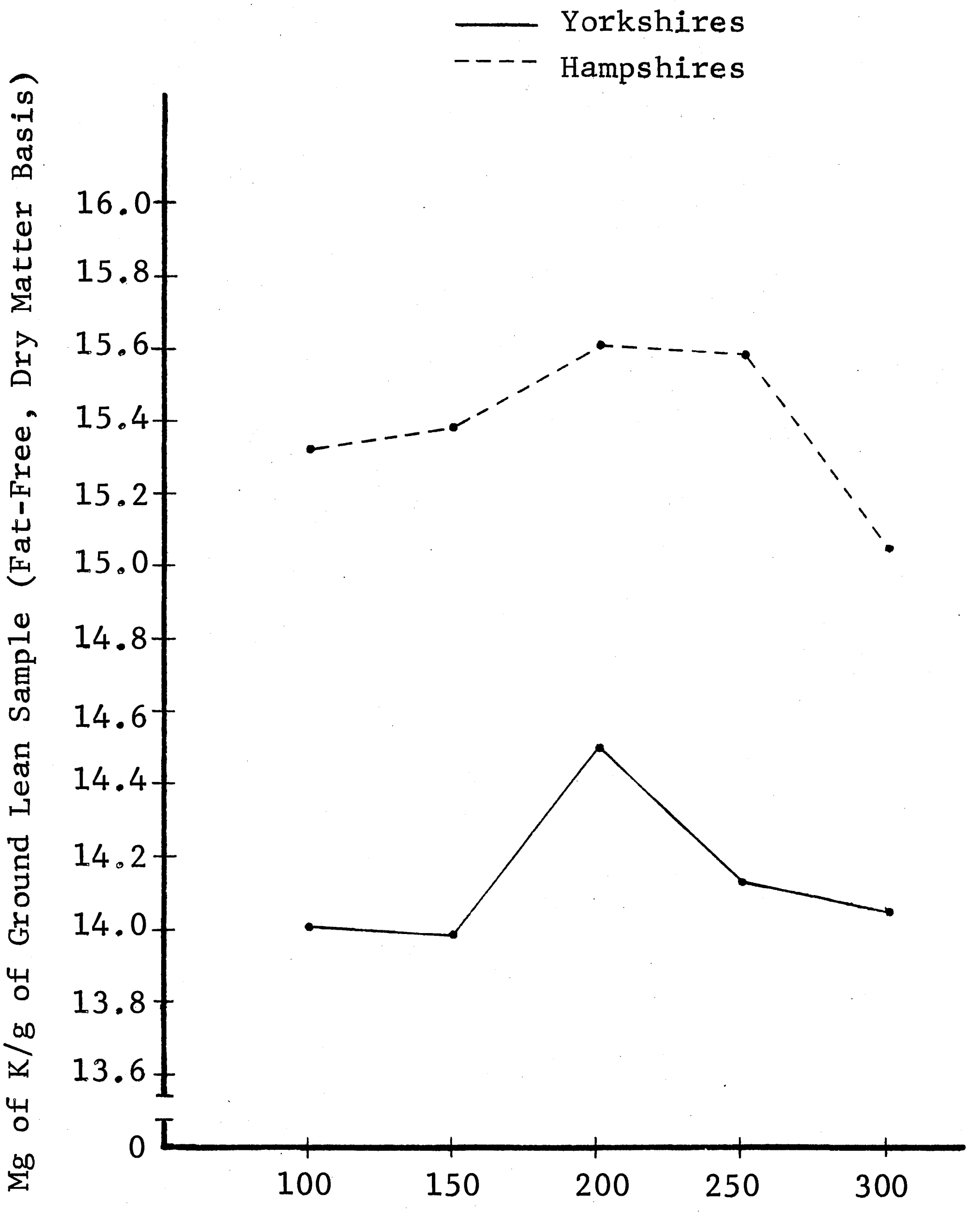

Figure 14. Mean Potassium Concentrations in the Separable Lean of Yorkshire and Hampshire Pigs at Different Weights.

Chemical Composition of Individual Muscles

An attempt was made to characterize the potassium concentration in the biceps femoris, semimembranosus, and longissimus dorsi muscles. Representative ground lean samples of the three individual muscles were chemically analyzed for ether-extract and moisture, as well as potassium content.

Results of the chemical analyses for potassium in the three muscles are presented in Table XXXII for Yorkshires and Hampshires. Means and standard errors are presented for the potassium concentration (expressed as mg of potassium per g of ground separable lean on a fat-free, dry matter basis) found in the three individual muscles from the Yorkshires and Hampshires. Because of the expense involved and observed trends in the potassium concentrations of the muscles, only the muscles from sixty pigs (20 Yorkshires and 40 Hampshires) were studied.

Slaughter weight was found to have a significant association with potassium concentrations in the longissimus dorsi and semimembranosus muscles for the Hampshires, but no significant effect on potassium concentration due to slaughter weight was found for the biceps femoris of the Hampshires and all three muscles of the Yorkshires (Appendix Tables XXXIX and XL).

Responses suggesting a linear relationship between potassium concentration and weight were observed for the

TABLE XXXII

MEANS AND STANDARD ERRORS FOR POTASSIUM CONCENTRATION IN CERTAIN MUSCLES FOR YORKSHIRE AND HAMPSHIRE PIGS AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Yorkshires, 4/wt. group					
Biceps femoris[a]	15.44±0.38	15.12±0.44	14.73±0.33	14.46±0.10	14.64±0.27
Longissimus dorsi	14.91±0.74	14.50±0.60	14.10±0.58	13.39±0.42	13.82±0.56
Semimembranosus	15.61±0.45	14.52±0.51	14.97±0.41	14.43±0.20	14.25±0.18
Hampshires, 8/wt. group					
Biceps femoris	16.75±0.63	16.46±0.40	15.88±0.32	15.55±0.22	15.43±0.18
Longissimus dorsi	17.15±0.46	16.47±0.42	15.43±0.29	14.37±0.39	15.24±0.16
Semimembranosus	17.24±0.37	16.39±0.35	15.99±0.30	15.44±0.33	15.79±0.12

[a] Mg of potassium per g of ground separable lean (fat-free, dry matter basis).

potassium content in the longissimus dorsi and semimembranosus muscles of the Hampshires from 100 to 250 pounds as shown in Figure 15. Decreases of 0.68, 1.04, and 1.06 mg K per g of ground separable lean for the longissimus dorsi and 0.85, 0.40, and 0.55 mg K per g of ground separable lean for the semimembranosus muscle were observed for each 50 pound increase in slaughter weight up to 250 pounds.

The potassium content in each of the three muscles of the Yorkshires also tended to decrease as slaughter weight increased (Figure 15) even though slaughter weight did not have a significant effect on potassium content (Appendix Table XXXIX). At 300 pounds slaughter weight, slight increases in potassium concentration were found for the biceps femoris and longissimus dorsi muscles of the Yorkshires and for the semimembranosus and longissimus dorsi muscles of the Hampshires. These results are not in general agreement with other researchers who have reported a decrease in the potassium concentration of lean with an increase in weight or age (Forbes, 1955; Holliday et al., 1957; and Moser, 1970).

Significant ($P \leq .05$) differences for potassium concentration between the three muscles (biceps femoris, longissimus dorsi, and semimembranosus muscles) were not found for either breed (Appendix Tables XLVII and XLVIII). These results are in agreement with Pfau and coworkers (1963) who found no significant differences between the semimembranosus and longissimus dorsi muscles from sixty pigs.

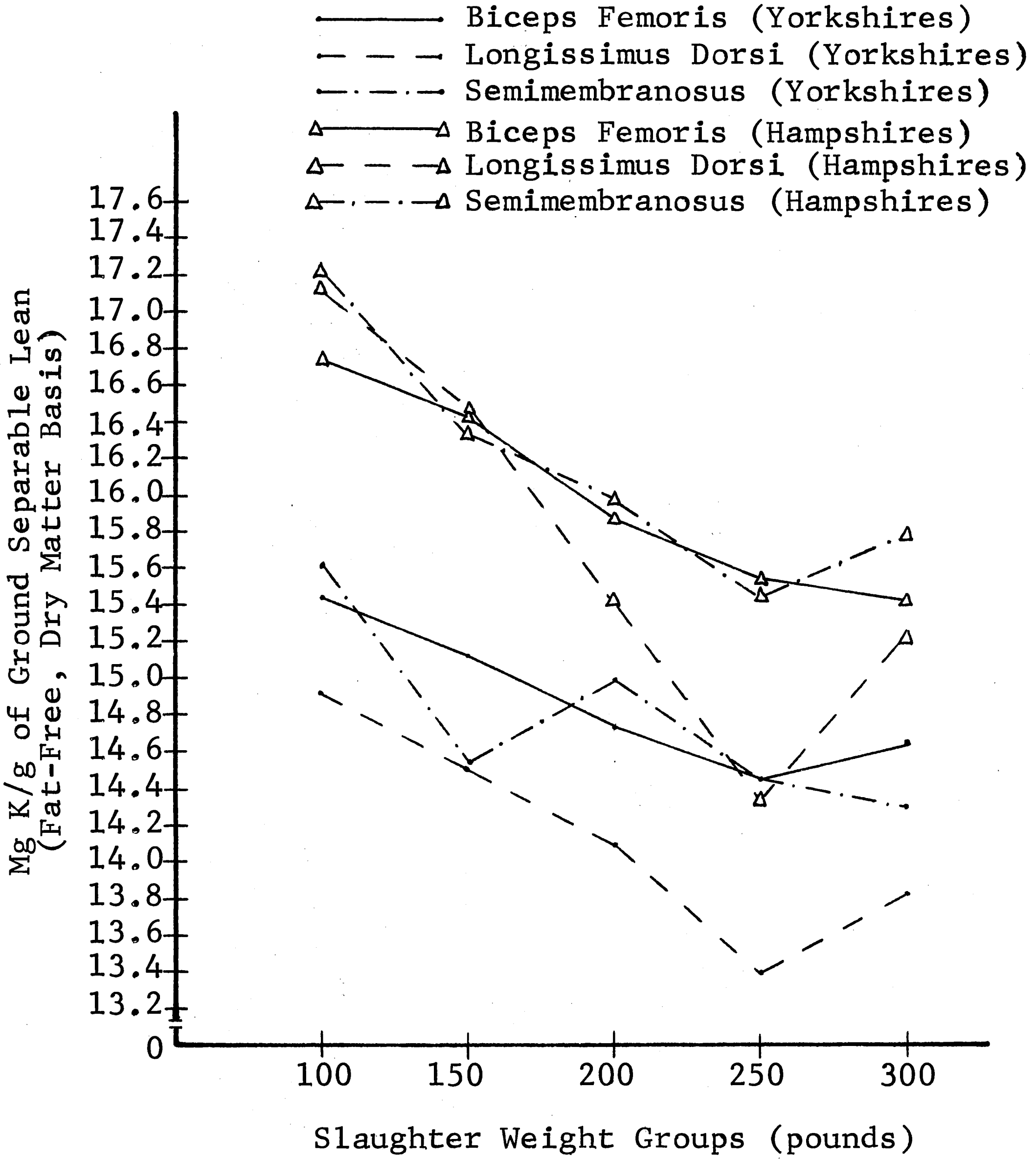

Figure 15. Mean Muscle Potassium Concentrations in Biceps Femoris, Longissimus Dorsi, and Semimembranosus Muscles for Yorkshires and Hampshires at Different Slaughter Weights.

Mullins et al. (1969) also found no significant differences when they compared the potassium concentrations in the ham, loin, and shoulder of 32 Duroc pigs. On the other hand, Gillett, Pearson, and Kirton (1965) found significant differences in the potassium content expressed on a wet basis, fat-free, moisture-free basis, and protein basis between anatomically different muscles of 12 pigs. Other researchers including Duggleby and Seebeck (1970), Lohman, Ball, and Norton (1970), and Holliday et al. (1957) also reported significant differences in the potassium content of different muscles.

In this study, the semimembranosus tended to have the highest potassium concentration at each weight, while the longissimus dorsi muscle generally had the lowest potassium concentration at each weight for both breeds as illustrated in Figure 15. Gillett and coworkers (1968) reported a 12.77 percent difference in the potassium content of four muscles of sheep when potassium was expressed on a fat-free, moisture-free basis. The researchers found that the longissimus dorsi had the least amount of potassium, followed by the semimembranosus, rectus femoris, and semitendinosus.

It appears from Figure 15 that the potassium content of the individual muscles for the Hampshire pigs was consistently greater than the potassium content of the biceps femoris, longissimus dorsi, and semimembranosus muscles for the Yorkshires at each weight. This observation is in agreement with Gillett, Pearson, and Kirton (1965) who found that Hampshires contained more potassium than Yorkshires on a per unit basis. In addition, differences in the potassium concentration of different breeds of cattle have been reported by Lohman and Norton (1968).

The means and standard errors for percent moisture in the biceps femoris, longissimus dorsi, and semimembranosus muscles are presented in Table XXXIII for Yorkshires and Hampshires.

Generally, as slaughter weight increased, percent moisture in the three individual muscles decreased for both breeds. Linearlike trends were observed for percent moisture in all three muscles of the Yorkshires and for the biceps femoris and semimembranosus muscles of the Hampshires as illustrated in Figure 16. In addition, slaughter weight was found to have a significant effect on percent moisture for the three individual muscles of both breeds, except for the longissimus dorsi of the Hampshires (Appendix Tables XXXIX and XL).

The decrease in percent moisture with increased slaughter weight for the individual muscles observed in this study is in agreement with results reported by Zinn (1967) and Hopper (1944). There was generally little difference in percent moisture between the three individual muscles at any specific weight for either breed; however, the semimembranosus had the greatest percent moisture at each of the slaughter weights.

TABLE XXXIII

MEANS AND STANDARD ERRORS FOR PERCENT MOISTURE IN CERTAIN MUSCLES FOR YORKSHIRE AND HAMPSHIRE PIGS AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Yorkshires, 4/wt. group					
Biceps femoris	74.71±0.47	73.10±0.79	72.01±0.45	72.03±0.61	71.41±0.65
Longissimus dorsi	74.42±0.57	73.23±0.75	72.33±1.09	72.41±0.24	71.72±0.56
Semimembranosus	75.63±0.24	74.39±0.62	73.42±0.56	73.05±0.56	71.90±0.25
Hampshires, 12/wt. group					
Biceps femoris	73.71±0.36	73.22±0.28	71.74±0.48	71.33±0.32	71.89±0.63
Longissimus dorsi	73.82±0.47	73.40±0.24	72.59±0.41	73.01±0.38	72.80±0.34
Semimembranosus	74.63±0.51	74.42±0.19	73.52±0.23	73.21±0.18	73.33±0.31

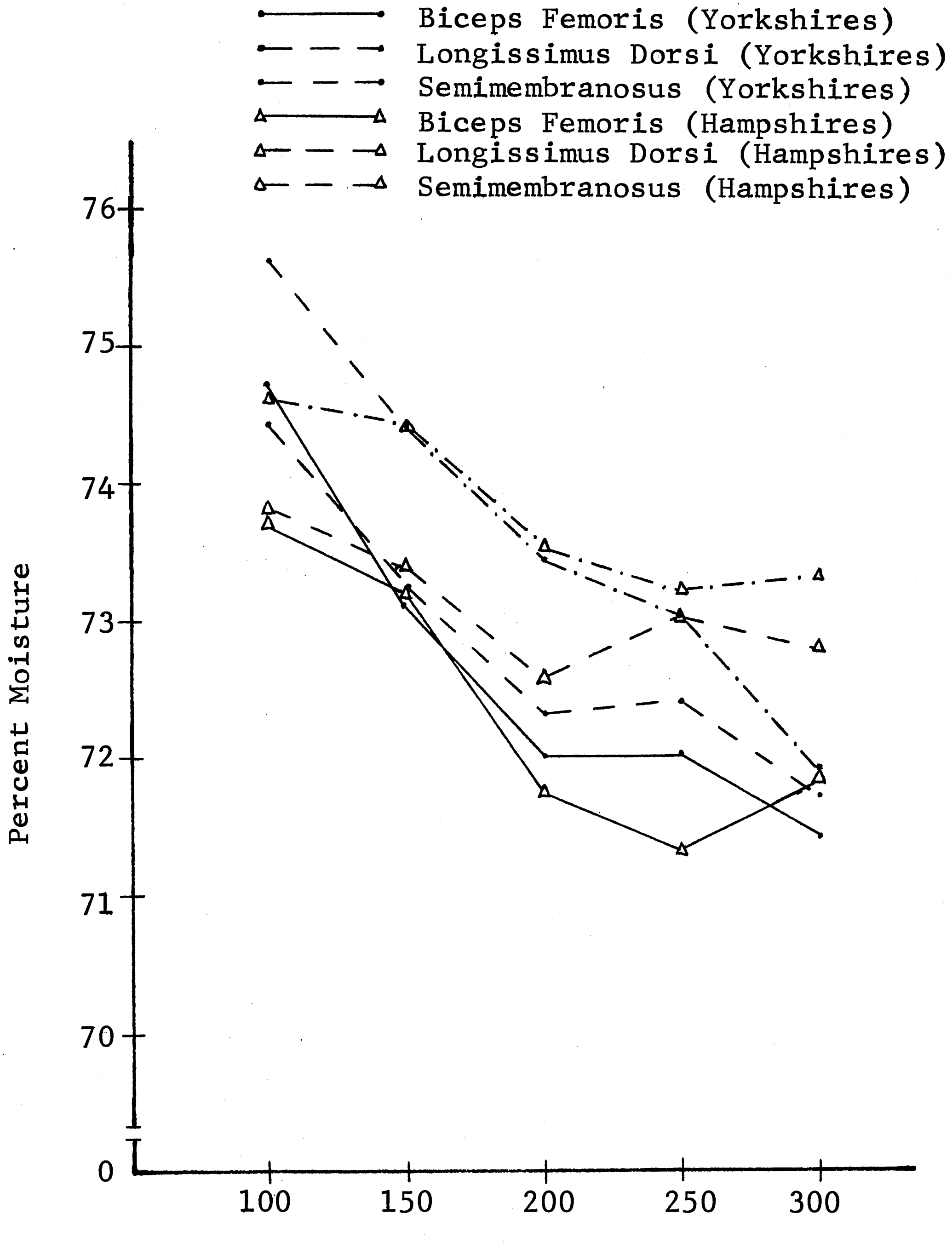

Figure 16. Mean Percent Moisture in Biceps Femoris, Longissimus Dorsi, and Semimembranosus Muscles for Yorkshire and Hampshire Pigs at Different Slaughter Weights.

The means and standard errors for ether-extract in the biceps femoris, longissimus dorsi, and semimembranosus muscles are presented in Table XXXIV for Yorkshires and Hampshires. The standard errors for percent ether-extract for the individual muscles at each weight for both breeds were quite large indicating considerable variation in percent ether-extract. Any adipose tissue covering the three muscles was trimmed as uniformly as possible; consequently, much of the variation in percent ether-extract found in the individual muscles at a specific weight should be due to differences in intramuscular fat deposition.

Generally, percent ether-extract increased as slaughter weight increased for the three muscles of the Yorkshires as illustrated in Figure 17. The same trend occurred for the biceps femoris and semimembranosus muscles of the Hampshires; however, percent ether-extract of the longissimus dorsi muscle was maintained at a uniform level with increased slaughter weight (Figure 17).

Slaughter weight was found to have a significant ($P \leq .05$) effect on percent moisture of the semimembranosus muscle for the Yorkshires and the biceps femoris and semimembranosus muscles for the Hampshires. Strong linear responses between percent moisture of the individual muscles and slaughter weight were not readily apparent as indicated by the response curves shown in Figure 17. The response curves for percent ether-extract (Figure 17) suggest that non-linear responses may have occurred in the heavier

TABLE XXXIV

MEANS AND STANDARD ERRORS FOR PERCENT ETHER-EXTRACT IN CERTAIN MUSCLES FOR YORKSHIRE AND HAMPSHIRE PIGS AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Yorkshires, 4/wt. group					
Biceps femoris	4.61±0.50	5.01±1.00	6.10±0.63	5.83±0.99	6.16±1.04
Longissimus dorsi	4.72±0.60	3.57±1.01	4.29±0.39	3.87±0.41	4.63±0.70
Semimembranosus	2.68±0.28	2.64±0.62	3.90±0.36	3.69±0.62	4.45±0.48
Hampshires, 12/wt. group					
Biceps femoris	5.51±0.45	6.22±0.29	7.32±0.64	7.48±0.48	7.36±0.70
Longissimus dorsi	4.76±0.57	4.84±0.36	5.13±0.52	4.79±0.42	5.13±0.40
Semimembranosus	3.46±0.30	3.73±0.17	4.24±0.33	4.46±0.23	4.88±0.33

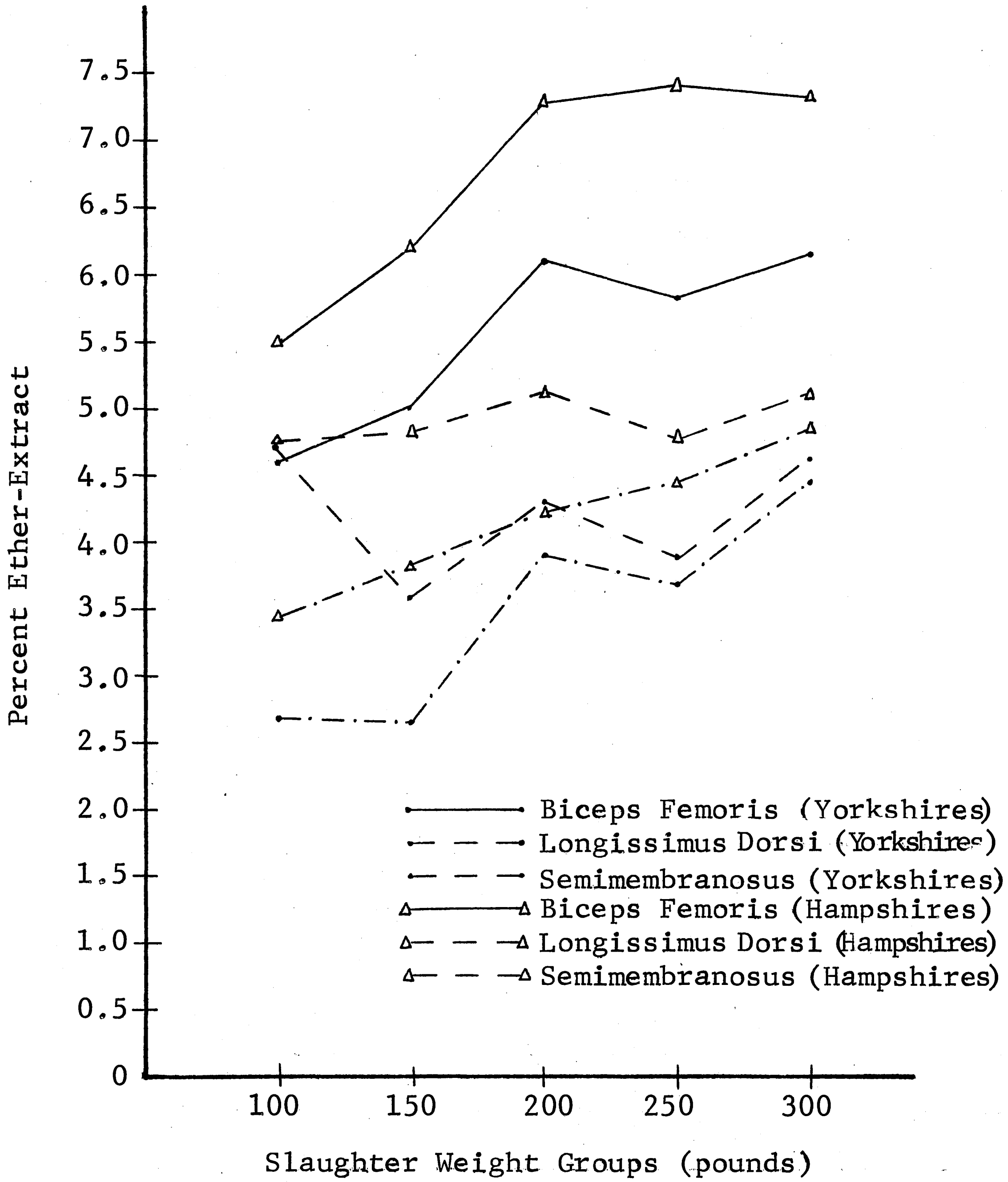

Figure 17. Mean Percent Ether-Extract in Biceps Femoris, Longissimus Dorsi, and Semimembranosus Muscles for Yorkshires and Hampshires at Different Weights.

weights for the semimembranosus and biceps femoris muscles for both breeds; however, significant non-linear effects were not found in the Yorkshire or Hampshire data.

The results concerning the biceps femoris and semimembranosus muscles are in agreement with Callow (1947), Zinn (1967), and Lawrie and Kirton (1956). The unusual responses for percent ether-extract of the longissimus dorsi muscle with increased weight for both breeds may have been due to the variation in intramuscular fat between pigs.

Percent ether-extract in the biceps femoris for each weight was found to be significantly ($P \leq .05$) greater than percent ether-extract in the longissimus dorsi and semimembranosus muscles for the Hampshires (Appendix Table L). However, in the Yorkshires, percent ether-extract in both the biceps femoris and longissimus dorsi muscles were significantly ($P \leq .05$) greater than percent ether-extract in the semimembranosus muscle at each weight (Appendix Table XLIX). These results are in agreement with Lawrie et al. (1963) who found that the longissimus dorsi muscle had a significantly greater intramuscular fat content than the semimembranosus muscle for pigs slaughtered at 150, 200, and 250 pounds. Zinn (1967) found a greater percent of ether-extract in the longissimus dorsi muscle than in the semimembranosus muscle of steers and heifers that had been on feed for at least 210 days; however, the difference was not found to be significant.

Generally, the Hampshires tended to have a greater percent of ether-extract at each weight for any of the three individual muscles when compared to the Yorkshires. The literature contains considerable evidence suggesting that breed does affect composition. Lawrie and Kirton (1956) reported that some breeds, within a specie, are early maturing and will fatten quicker than a later maturing animal. These results further support the idea that the Hampshires used in this study were earlier maturing than the Yorkshires.

CHAPTER V

SUMMARY

The primary objectives of this study were to evaluate the association of live and carcass measurements with carcass leanness in pigs slaughtered at five different weights and to observe the association of slaughter weight with certain live estimates, carcass measurements and carcass composition. Thirty Yorkshire and seventy Hampshire barrows representing five weight groups (100, 150, 200, 250, and 300 pounds) were evaluated using two live techniques, potassium-40 and backfat probe. The pigs were obtained from the University herds and were uniformly very muscular, large framed pigs that were not representative of pigs (of these weights) found in the present swine industry. As the pigs reached the shrunk live weights of 100, 150, 200, 250, and 300 pounds, they were taken off feed for 24 hours and evaluated, irrespective of final slaughter weight. Upon reaching the pre-determined slaughter weight, the pigs were evaluated for the final time and then transported to the O.S.U. Meat Laboratory for slaughter and carcass composition determination.

Correlation coefficients between first and second K^{40} counts were determined on the live animals to establish the repeatability of the O.S.U. whole-body counter during the study. Correlation coefficients between first and second K^{40} counts for the weight groups 100, 150, 200, 250, and 300 pounds were found to be 0.800, 0.916, 0.923, 0.945, and 0.920, respectively, indicating that there was good agreement between the two readings and that the K^{40} whole-body counter was repeating itself reasonably well.

The mean K^{40} counts per minute ranged from 3641 to 6494 for the Yorkshires and 3747 to 6171 for the Hampshires for the 100 and 300 pound weight groups, respectively. Mean K^{40} counts per minute increased as slaughter weight increased; however, the rate of increase declined at the heavier weights for both breeds. The most rapid increase in net K^{40} counts per minute for both breeds occurred between the 100 and 150 pound weights, and the smallest increase in K^{40} counts occurred between the 250 and 300 pound weight interval for both breeds.

In an effort to estimate backfat thickness, a live probe was taken on each pig prior to slaughter using a Duncan Lean Meter. The average backfat thickness estimated by the Duncan Lean Meter ranged from 0.59 to 1.36 inches for the Yorkshires and from 0.61 to 1.43 inches for the Hampshires. Live backfat probe increased as slaughter weight increased for each breed; however, the rate of increase in backfat probe was much greater at the heavier weights (especially for the Hampshires) than at the lighter weights.

Fat-free lean was used as the compositional end point for lean in this study since this trait most closely represented the true lean composition of the pigs. The mean pounds of fat-free lean ranged from 38.01 to 110.84 for the Yorkshires and 39.23 to 100.51 for the Hampshires. The stage of most rapid increase in pounds of fat-free lean was found to be 200 to 250 pounds for both breeds, while the least increase occurred between 250 and 300 pounds for both Yorkshires and Hampshires. A linearlike trend was observed for fat-free lean for both breeds from 100 to 250 pounds; however, a slight decline in rate of increased pounds of fat-free lean occurred from 250 to 300 pounds for both breeds.

Linearlike trends were observed for fat in both breeds, especially from 150 to 300 pounds. As expected, the stage of most rapid fat deposition occurred from 250 to 300 pounds, while the least occurred from 100 to 150 pounds for both breeds. Generally, fat-free lean and bone decreased as slaughter weight increased, when expressed as a percentage of carcass weight for each breed, while the opposite trend was observed for fat.

Slaughter weight was found to have a significant ($P \leq .01$) effect on mean pounds of lean cuts, ham and loin, and ham. Rather uniform increases were observed for these traits as slaughter weight increased for both breeds. A slight decrease in pounds of lean cuts, when expressed on a carcass weight basis, was observed with increased slaughter weight for both breeds; however, very little change occurred in pounds of ham and loin and ham (expressed as a percentage of carcass weight) with increased slaughter weight for both breeds.

The biceps femoris and semimembranosus muscles were removed in their entirety and gross weights taken in an effort to characterize growth and to also determine the validity of using muscle weights to predict total carcass lean. Gross weights for the biceps femoris and semimembranosus muscles increased as slaughter weight increased for each breed. The greatest increase in growth for both muscles for each breed occurred between 200 and 250 pounds live weight. Generally, the muscle weights when expressed as a percentage of carcass weight, decreased with increased slaughter weight.

Correlation coefficients for mean K^{40} count and live backfat probe with fat-free lean, lean cuts, ham, ham and loin, loin eye area, and carcass backfat were found to be significant ($P \leq .05$) for each breed. The correlation coefficients ranged from 0.923 (loin eye area) to 0.406 (ham and loin) for K^{40} count and 0.894 (carcass backfat) to -0.310 (loin eye area) for live backfat probe for both breeds.

Prediction equations were developed using the live estimates of weight, K^{40} count, and live backfat probe to estimate pounds of fat-free lean in pigs weighing 100, 150, 200, 250, and 300 pounds. The prediction equations containing the three live estimates were found to be the most accurate in predicting pounds of fat-free lean and had standard errors of estimate of 3.91 and 4.44 pounds for Yorkshires and Hampshire, respectively. Regression equations that included live backfat probe contributed the least insofar as removing variation in estimating pounds of fat-free lean.

Correlation coefficients between the biceps femoris and semimembranosus muscles and several carcass measurements including fat-free lean, lean cuts, and loin eye area were found to be significant ($P \leq .05$) for both breeds. The relationships between each of the individual muscle weights and the previously mentioned traits were not very strong and accounted for only 9 to 36 percent of the variation associated with those traits in question. It appeared from the data that neither biceps femoris nor semimembranosus weights had strong enough relationships to serve as reliable predictors of fat-free lean in heavily muscled pigs.

Prediction equations were developed using the weights of the two muscles as independent variables and fat-free lean as the dependent variable. The prediction equations containing both muscle weights were the most accurate in predicting pounds of fat-free lean accounting for 88.3 and 92.6 percent of the variation associated with fat-free lean and having standard errors of estimate of 7.94 and 8.32 pounds for Yorkshires and Hampshires, respectively. The prediction equations composed of live animal estimates were superior in predicting fat-free lean than those using muscle weights as coefficients of determination were increased by 10 percent and standard errors of estimate reduced by 4 pounds.

Significant ($P \leq .01$) correlations between fat-free lean (expressed as pounds or percent) and several carcass measurements including lean cuts, ham, ham and loin, loin eye area, and backfat thickness were found for both Yorkshires and Hampshires. In general, the carcass measurements studied were in good agreement with fat-free lean expressed as pounds or as a percent of slaughter weight and would account for 40 to 70 percent of the variation in fat-free lean. Slightly lower correlation coefficients were found between lean cuts and the same carcass measurements that were correlated with fat-free lean.

Ether-extract, moisture, and potassium analyses were conducted on ground lean samples of the right carcass halves. Generally, percent ether-extract increased and percent moisture decreased as slaughter weight increased for each breed. Very little change occurred in the potassium content of ground separable lean with increased slaughter weight; however, a slight decrease in mg of potassium per g of ground separable lean (fat-free, dry matter basis) was found from 200 to 300 pounds for both breeds.

The biceps femoris, longissimus dorsi, and semimembranosus muscles were chemically analyzed for potassium, as well as ether-extract and moisture. The potassium content for the individual muscles tended to decrease as slaughter weight increased for both breeds. Significant differences in potassium concentration between the three individual muscles were not observed for either breed; however, the semimembranosus and biceps femoris muscles generally contained more potassium at each weight for both breeds. A breed difference was observed with the muscles from the Hampshire pigs containing at least 6 percent more potassium at any specific weight as compared to those individual muscles of the Yorkshires.

As weight increased, percent moisture tended to decrease in the three individual muscles, especially for the Yorkshires. There was generally little difference in percent moisture between the three muscles for any specific weight for each breed; however, the semimembranosus muscle was found to have the greatest percent moisture at each weight for both breeds.

Generally, percent ether-extract increased as slaughter weight increased for the three muscles of the Hampshires; however, percent ether-extract of the longissimus dorsi muscle was maintained at a uniform level with increased slaughter weight. Percent ether-extract in the biceps femoris muscle was found to be ($P \leq .05$) 2 to 3 percent greater for each weight group than the percent ether-extract in the semimembranosus muscle for both breeds. In addition, the Hampshires tended to have a higher percent of ether-extract at each weight for each of the three individual muscles when compared to the Yorkshires.

In conclusion, it appeared that the O.S.U. whole-body counter was superior to live backfat probe in predicting the lean composition of swine with increased weight and age. In addition, the data indicated that the O.S.U. whole-body counter may have the potential to accurately predict the muscle content in younger, light weight pigs. However, further research involving greater numbers of pigs with greater variation in composition than those used in this study is needed to develop accurate prediction equations which may be useful to swine breeders and feeders.

LITERATURE CITED

A.O.A.C. 1965. Official Methods of Analysis (10th Ed.) Association of Official Agriculture Chemists. Washington, D. C.

Adams, James P. 1971. Live and carcass measurements as indicators of lean cut yield in swine. Masters Thesis. Okla. State Univ., Stillwater.

Addison, C. E. 1973. The use of ^{40}K counter as an estimator of lean yield in swine. Masters Thesis. Okla. State Univ., Stillwater.

Addison, Conall E., I. T. Omtvedt, and L. E. Walters. 1971. Association between certain live and carcass measurements in swine. Okla. Agr. Exp. Sta. Misc. Pub. 85:69.

Addison, C. E., I. T. Omtvedt, L. E. Walters, R. K. Johnson, and R. F. Queener. 1972. Using live K^{40} count to estimate leanness in pigs. Okla. Agr. Exp. Sta. Misc. Pub. 87:111.

Allen, L. B., H. R. Thomas, P. O. Graham, R. F. Kelly, and C. C. Brooks. 1961. Effect of slaughter weight on composition and efficiency of swine. J. Animal Sci. 20:923 (Abstr.).

Anderson, E. C. 1959. Data Reduction for the Los Alamos Human Counter. Los Alamos Scientific Laboratory, Los Alamos, New Mexico. p. 23.

Anderson, E. C. and W. H. Langham. 1959. Average potassium concentration of the human body as a function of age. Science 130:713.

Arganosa, V. G. 1968. The influence of genetic factors on pork quality. Ph.D. Thesis. Okla. State Univ., Stillwater.

Barlow, J. S. and J. F. Manery. 1954. The changes in electrolytes, particularly chloride, which accompany growth in chick muscle. J. Cellular and Comparative Physiol. 43:165.

Bennink, M. R., G. M. Ward, J. E. Johnson, and D. A. Cramer. 1968. Potassium content of carcass components and internal organs of cattle as determined by K^{40} and atomic absorption spectrometry. J. Animal Sci. 27:600.

Blaxter, K. L. and J. A. F. Rook. 1956. The indirect determination of energy retention in farm animals. I. The development of method. J. Agr. Sci. 48:194.

Breidenstein, B. C., T. G. Lohman, G. S. Smith, and H. W. Norton. 1965a. Comparison of ^{40}K measurement with other methods for determining lean muscle mass in sheep. J. Animal Sci. 24:860 (Abstr.).

Breidenstein, B. C., T. G. Lohman, G. S. Smith, and H. W. Norton. 1965b. ^{40}K and other indices of carcass lean muscle mass in pigs. J. Animal Sci. 24:860 (Abstr.).

Briskey, E. J., R. W. Bray, W. G. Hockstra, P. H. Phillips, and R. H. Grummer. 1959a. The chemical and physical characteristics of various pork ham muscle classes. J. Animal Sci. 18:146.

Briskey, E. J., R. W. Bray, W. G. Hockstra, R. H. Grummer, and P. H. Phillips. 1959b. The effect of various levels of exercise in altering the chemical and physical characteristics of certain pork ham muscles. J. Animal Sci. 18:153.

Butterfield, R. M. 1965. The relationship of carcass measurements and dissection data to beef carcass composition. Research Vet. Sci. 6:24.

Callow, E. H. 1947. Comparative studies of meat. I. The chemical composition of fatty and muscular tissue in relation to growth and fattening. J. Agr. Sci. 37:113.

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

Callow, E. H. 1962. The relationship between the weight of a tissue in a single joint and the total weight of the tissue in a side of beef. Animal Prod. 4:37.

Cheek, D. B. and C. D. West. 1955. An appraisal of methods of tissue chloride analysis: the total carcass chloride, exchangeable chloride, potassium and water of the rat. J. Clin. Invest. 34:1744.

Clark, J. L., H. B. Hedrick, G. B. Thompson, J. G. Riley, W. L. Mies, R. J. Epley, and R. L. Preston. 1972. Level and distribution of potassium in beef carcasses. J. Animal Sci. 35:542.

Conway, E. J. 1957. Nature and significance of concentration relations of potassium and sodium ions in skeletal muscle. Physiol. Rev. 37:84.

Corsa, L., Jr., J. M. Olney, Jr., R. W. Steenburg, M. R. Ball, and F. D. Moore, 1950. The measurement of exchangeable potassium in man by isotope dilution. J. Clin. Investig. 29:1280.

Duggleby, J. C. and R. M. Seebeck. 1967. Potassium and caesium-137 distributions in Angus steer carcasses. J. Agr. Sci. 69:149.

Flear, C. T. G., R. G. Carpenter, and Irene Florence. 1965. Variability in water, sodium, potassium, and chloride content of human skeletal muscle. J. Clin. Path. 18:74.

Forbes, G. B. 1955. Inorganic chemical heterogony in man and animals. Growth 19:75.

Forbes, G. B. 1963. Nutritional implications of the whole body counter. Nutr. Rev. 21:321.

Forbes, G. B. and A. M. Lewis. 1956. Total sodium, potassium, and chloride in adult man. J. Clin. Investig. 35:596.

Frahm, R. R., L. E. Walters, and C. R. McLellan, Jr. 1971. Evaluation of K^{40} count as a predictor of muscle in yearling beef bulls. J. Animal Sci. 32:463.

Gillett, T. A., A. M. Pearson, D. M. Allen, and R. A. Merkel. 1967. Variation in potassium and sodium content of bovine muscles. J. Animal Sci. 26:46.

Gillett, T. A., A. M. Pearson, and A. H. Kirton. 1965. Variation in potassium and sodium in muscles of the pig. J. Animal Sci. 24:177.

Gillett, T. A., A. M. Pearson, R. A. Merkel, and W. T. Magee. 1968. Potassium and sodium content of muscle from sheep with high and low blood potassium. J. Animal Sci. 27:645.

Green, R. M., K. G. McNeill, and G. A. Robinson. 1961. The distribution of potassium and caesium-137 in the calf and the pig. Can. J. Biochem. Physiol. 39:1021.

Hazel, L. N. and E. A. Kline. 1959. Ultrasonic measurement of fatness in swine. J. Animal Sci. 18:815.

Holliday, M. A., W. E. Segar, A. Lukenbill, R. M. Valencia, and A. M. Durell. 1957. Variations in muscle electrolyte composition due to sampling and to aging. Proc. Soc. Exper. Biol. Med. 95:786.

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

Johnson, R. K., L. E. Walters, and J. V. Whiteman. 1972. Importance of different levels of potassium in the diet on whole-body ^{40}K count and muscle and blood potassium. J. Animal Sci. 35:931.

Judge, M. C., M. Strob, W. V. Kessler, and J. E. Christianson. 1963. Lamb carcass and live lamb evaluations by potassium-40 and carcass measurements. J. Animal Sci. 22:418.

Karvis, E. M. and M. R. Kare. 1960. Changes with age in tissue levels of sodium and potassium in the fowl. Poultry Sci. 39:13.

Kirton, A. H., R. H. Gnaedinger, and A. M. Pearson. 1963. Relation of potassium and sodium content to the composition of pigs. J. Animal Sci. 22:904.

Kirton, A. H. and A. M. Pearson. 1963. Comparison of methods of measuring potassium in pork and lamb and prediction of their composition from sodium and potassium. J. Animal Sci. 22:125.

Kirton, A. H., A. M. Pearson, R. H. Nelson, E. C. Anderson, and R. L. Schuch. 1961. The use of naturally occurring ^{40}K to determine the carcass composition of live sheep. J. Animal Sci. 20:635.

Kulwich, R., L. Feinstein, and E. C. Anderson. 1958. Correlation of potassium-40 concentration of fat-free lean content of hams. Science 127:338.

Kulwich, R., L. Feinstein, and C. Golumbic. 1960. Beta radioactivity of the ash in relation to the composition of the ham. J. Animal Sci. 19:119.

Kulwich, R., L. Feinstein, C. Golumbic, W. R. Seymour, W. R. Kauffman, and R. L. Hiner. 1961. Relation of gamma-ray emission to the lean content of beef rounds. Food Tech. 15:411.

Lasley, E. L., L. N. Hazel, and E. A. Kline. 1956. Predicting lean cuts from live hog and easily measured carcass traits. J. Animal Sci. 15:1268 (Abstr.).

Lawrie, R. A. and A. H. Kirton. 1956. Systematic analytical differences between psoas major and longissimus dorsi muscles of cattle. British J. Nutr. 15:453.

Lawrie, R. A. and R. W. Pomeroy. 1963. Sodium and potassium in pig muscle. J. Agr. Sci. 61:409.

Lohman, T. G., R. H. Ball, and H. W. Norton. 1970. Biological and technical sources of variability in bovine carcass lean tissue composition. II. Biological variation in potassium, nitrogen and water. J. Animal Sci. 30:21.

Lohman, T. G., B. C. Breidenstein, A. R. Twardock, G. S. Smith, and H. W. Norton. 1966. Symposium on atomic energy in animal science. Estimation of carcass lean muscle mass in steers by K-40 measurement. J. Animal Sci. 25:1218.

Lohman, T. G., R. C. Dieter, and H. W. Norton. 1970. Biological and technical sources of variability in bovine carcass lean tissue composition. I. Technical variation in measurement of potassium, nitrogen and water. J. Animal Sci. 30:15.

Lohman, T. G., E. E. Hatfield, V. S. Garrigus, B. C. Breidenstein, and B. B. Doane. 1965. Use of ^{40}K in sheep research. Ill. Agr. Exp. Sta. Sheep Day.

Lohman, T. G. and H. W. Norton. 1968. Distribution of potassium in steers by ^{40}K measurement. J. Animal Sci. 27:1266.

Lohman, T. G., O. B. Ross, B. C. Breidenstein, A. R. Twardock, A. L. Newmann, and G. S. Smith. 1964. Estimation of fat-free lean tissue in live cattle and carcasses by measurement of K-40. J. Animal Sci. 23:862.

Lowry, O. H., A. B. Hastings, T. Z. Hull, and A. N. Brown. 1942. Histochemical changes associated with aging. II. Skeletal and cardiac muscle in the rat. J. Biol. Chem. 143:271.

Manery, J. F. 1954. Water and electrolyte metabolism. Physiol. Rev. 34:334.

Martin, T. G., W. V. Kessler, E. G. Stant, Jr., J. E. Christian, and F. N. Andrews. 1963. Body composition of calves and pigs measured by large volume liquid scintillation counting and conventional chemical analyses. Ann. N. Y. Acad. Sci. 110:213.

McLellan, C. R., Jr. 1970. Analysis of a permian potassium-40 counter as a predictor of lean in beef cattle. Masters Thesis. Okla. State Univ., Stillwater.

McMeekan, C. P. 1941. Growth and development in the pig, with special reference to carcass quality characters. IV. The use of sample joints and of carcass measurements as indices of the composition of the bacon pig. V. The bearing of the main principles emerging upon the many problems of animal production and human development. J. Agr. Sci. 31:1.

McMeekan, C. P. 1959. Principles of Animal Production. Whitcombe and Tombe, Ltd.

Mitteldorf, A. J. and D. O. Landon. 1952. Spectrochemical determination of the mineral-element content of beef. Anal. Chem. 24:469.

Moser, B. D. 1970. The association between certain live and carcass measurements in growing and finishing swine. Masters Thesis. Okla. State Univ., Stillwater.

Mounib, M. S. and J. V. Evans. 1957. Comparison between three methods used for the preparation of tissues for determinations of potassium and sodium. Analyst 92:522.

Mounib, M. S. and J. V. Evans. 1960. The potassium and sodium contents of sheep tissues in relation to the potassium content of the erythrocytes and the age of the animal. J. Biochem. 75:77.

Muldowney, F. P., J. Crooks, and M. M. Bluhm. 1957. The relationship of total exchangeable potassium and chloride to lean body mass, red cell mass, and creatinine in man. J. Clin. Investig. 36:1375.

Mullins, M. F., H. B. Hedrick, S. E. Zobrisky, W. J. Coffman, and C. V. Gehrke. 1969. Comparison of potassium and other chemical constituents as indices of pork carcass composition. J. Animal Sci. 28:192.

Mullins, M. F., S. E. Zobrisky, H. B. Hedrick, and M. A. Alexander. 1968. Indices of pork carcass composition. J. Animal Sci. 27:1122.

Munson, A. W., J. V. Whiteman, and L. E. Walters. 1966. A method for estimating ether extract in the boneless portion of lamb carcasses. J. Animal Sci. 25:967.

Omtvedt, I. T., D. F. Stephens, D. R. Rule, and W. E. Sharp. 1967. Relationship between growth rate, probe backfat thickness, and carcass traits in swine. Okla. Agr. Exp. Sta. Misc. Pub. 79:26.

Omtvedt, I. T., L. E. Walters, John Mabry, R. K. Johnson, and R. F. Queener. 1973. The relationship between backfat thickness and loin eye area measurements and the weight of the lean cuts in swine carcasses. Okla. Agr. Exp. Sta. Misc. Pub. 90:114.

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

Palsson, H. and J. B. Verges. 1952. Effects of the plane of nutrition on growth and the development of carcass quality in lambs. Part II. Effects on lambs of 30 lb. carcass weight. J. Agr. Sci. 42:93.

Pearson, A. M., J. F. Price, J. A. Hoefer, L. J. Bratzler, and W. T. Magee. 1957. A comparison of the live probe and lean meter for predicting various carcass measurements of swine. J. Animal Sci. 16:481.

Pfau, A. 1965. Interpretation problems of whole-body potassium measurements studied on various components of dissected pigs. Radioactivity in Man. G. R. Meneely, Ed. Cited from Lohman and Norton. 1968.

Pfau, Von A. and G. Kallistratos. 1963. Untersuchungen zur Bestimmung von Korperbestandteilen lebender Schweine uber ^{40}K-Gamma-Radioaktivitatsmessungen. II. Der. Kaliumgehalt der Muskulatur eines 110 kg schweren Schweines. Z. Tierz. Zuchtungsbiol. 79:249.

Pfau, Von A., G. Kallistratos, B. Ossowski, H. Hoeck. and Z. Zivkovic. 1963. Untersuchungen zur Bistimmung Von Korperbestandteilen lebender Schweine uber 40 K-gamma radioaktivitatsmess-ungen. I. Der Kaliungehalt des M. longissimus dorsi unddes M. semimembranosus bei 1loky Schweren Schweinen untershiredlichen Geschlechts and Rasse. Z. Tierz. Zuchtungsbiol. 78:170. Cited from Kirton, Gnaedinger, and Pearson (1963).

Service, J. 1972. A User's Guide to the Statistical Analysis System. North Carolina State Univ., Raleigh, N. C.

Smith, G. S., T. G. Lohman, A. R. Twardock, and B. C. Breidenstein. 1965. An animal's natural radioactivity is a measure of meatiness. Ag. Exp. Sta. Cattle Feeders Report.

Spray, C. M. and E. M. Widdowson, 1950. The effect of growth and development on the composition of mammals. British J. Nutr. 4:332.

Stant, E. G., Jr. 1963. Body composition of calves measured by large volume liquid scintillation counting and chemical analyses. Masters Thesis. Purdue Univ.

Stant, E. G., T. G. Martin, and W. F. Kessler. 1969. Potassium content in the small and large intestine. Amer. J. Physiol. 21:607.

Steel, G. D. and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc., New York.

Swift, C. E. and M. D. Berman. 1959. Factors affecting the water retention of beef. I. Variations in composition and properties among eight muscles. Food Tech. 13:365.

Talso, P. J., C. E. Miller, A. J. Carballo, and I. Vasquez. 1960. Exchangeable potassium as a parameter of body composition. Metabolism 9:456.

Twardock, A. R., T. G. Lohman, G. S. Smith, and B. C. Breidenstein. 1966. Part I: The Illinois Animal Science Counter; Performance characteristics and animal radioactivity measurement procedures. J. Animal Sci. 25:1209.

Van Dilla, M. A. and E. C. Anderson. 1962. Human counters using liquid scintillators, p. 41. In Whole-body counting. International Atomic Energy Agency, Vienna.

Van Dilla, M. A., G. R. Farmer, and V. R. Bohman. 1961. Fallout radioactivity in cattle and its effects. Science 133:1075.

Varney, W. Y., J. D. Kemp, C. D. Phillips, and C. E. Barnhart. 1962. Relative cut-out percentages and values of light and heavier weight hogs. J. Animal Sci. 21:377 (Abstr.).

Ward, G. M., J. E. Johnson, and T. R. Tyler. 1967. Relationship of potassium measured as K^{40} to the moisture and fat of ground beef. J. Animal Sci. 26:298.

Woodward, K. T., T. T. Trujillo, R. L. Schuch, and E. C. Anderson. 1956. Correlation of total body potassium with body water. Nature 178:97.

Zinn, D. W. 1967. Quantitative and qualitative beef carcass characteristics as influenced by time on feed. Ph.D. Dissertation. Univ. of Missouri, Columbia, Missouri.

Zobrisky, S. E. 1963. How pigs grow and fatten. Mo. Swine Day.

Zobrisky, S. E., H. D. Naumann, J. F. Lasley, D. E. Brady, and A. M. Mullins. 1958. Physical composition of swine during growth and fattening. Mo. Agr. Exp. Sta. Res. Bul. 672.

APPENDIX

TABLE XXXV

MEAN SQUARE VALUES AND LINEAR AND QUADRATIC RELATIONSHIPS BETWEEN WEIGHT AND DIFFERENT CARCASS MEASUREMENTS ON YORKSHIRE PIGS

Measurements	Slaughter Weight S.S.	Slaughter Weight M.S.	Linear S.S.	Quadratic S.S.	Other S.S.	E.M.S.
Carcass wt., lbs.	93,690	23,423**	99,664**	0.535	25.62	18.93
Backfat, in.	1.843	0.461**	1.628**	0.214**	0.001	0.014
Loin eye area, sq. in.	4,590	1,147.5**	4,560**	15.48	14.49	15.44
Carcass length, in.	297.92	74.48**	293.58**	3.47*	0.869	0.417
Dressing percent	233.24	58.31**	216.44**	13.62	3.178	6.25
Fat-free lean, lbs.	21,086	5,272**	21,041**	2.34	43.86	32.15
% slaughter wt., lbs.	9.01	2.25	0.030	0.126	8.86	8.52
% carcass wt., lbs.	142.77	35.69	128.36**	7.11	7.30	15.38
Pounds per day of age	3.12	0.78	2.41**	0.610**	0.010	0.534
Fat, lbs.	16,240	4,060**	16,217**	17.01	6.339	40.62
% slaughter wt., lbs.	412.13	103.03**	396.58**	14.97	0.573	9.46
% carcass wt., lbs.	493.67	123.42**	469.82**	20.90	2.96	16.56
Bone, lbs.	1,070	268**	1,066**	0.569	3.289	3.75
% slaughter wt., lbs.	29.47	7.37**	25.25**	2.04	2.18	1.19
% carcass wt., lbs.	120.33	30.08**	105.07**	9.80*	5.46	2.00
Lean cuts, lbs.	28,656	7,164**	28,594**	4.66	57.3	36.60
% slaughter wt., lbs.	18.04	4.51	3.60	1.98	12.45	8.28
% carcass wt., lbs.	109.09	27.27	95.53**	2.19	11.366	13.59

* $P \leq .05$

** $P \leq .01$

TABLE XXXVI

MEAN SQUARE VALUES AND LINEAR AND QUADRATIC RELATIONSHIPS BETWEEN WEIGHT AND DIFFERENT CARCASS MEASUREMENTS ON HAMPSHIRE PIGS

Measurements	Slaughter Weight S.S.	Slaughter Weight M.S.	Linear S.S.	Quadratic S.S.	Other S.S.	E.M.S.
Carcass wt., lbs.	213,420	53,355**	213,377**	4.29	39.16	8.45
Backfat, in.	5.41	1.353**	5.39**	0.010	0.011	0.015
Loin eye area, sq. in.	7,105	1,776.25**	6,385**	675.33**	44.57	36.43
Carcass length, in.	614.13	153.53**	600.12**	11.93**	2.088	0.449
Dressing percent	503.44	125.86**	468.16**	27.44*	7.831	2.85
Fat-free lean, lbs.	33,852	8,463**	33,615**	133.24*	104.44	30.78
% slaughter wt., lbs.	245.43	61.36**	218.83**	1.86	24.74	7.22
% carcass wt., lbs.	1,363	340.75**	1,331**	8.78	23,956	15.72
Pounds per day of age	4.21	1.05**	3.34**	0.710**	0.015	0.081
Fat, lbs.	55,255	13,813.75**	54,891**	323.34*	41.231	38.73
% slaughter wt., lbs.	2,080	520**	2,052**	19.85	8.40	9.45
% carcass wt., lbs.	3,448	862**	3,305**	94.36	49.39	59.28
Bone, lbs.	2,122	530.50**	2,108**	4.57	9.753	2.76
% slaughter wt., lbs.	64.72	16.18**	60.49**	1.85	2.376	0.852
% carcass wt., lbs.	249.89	62.47**	235.40**	11.50	3.003	1.64
Lean cuts, lbs.	51,137	12,784**	50,660**	252.37**	224.96*	34.72
% slaughter wt., lbs.	191.23	47.81**	120.55**	20.97	49.71	8.03
% carcass wt., lbs.	1,181	295.38**	1,126**	1.10	54.384	16.98

* $P \leq .05$

** $P \leq .01$

TABLE XXXVII

MEAN SQUARE VALUES AND LINEAR AND QUADRATIC RELATIONSHIPS BETWEEN WEIGHT AND DIFFERENT CARCASS MEASUREMENTS ON YORKSHIRE PIGS

Measurements	Slaughter Weight S.S.	Slaughter Weight M.S.	Linear S.S.	Quadratic S.S.	Other S.S.	E.M.S.
Ham and loin, lbs.	8,479	2,119**	8,464**	0.160	15.29	9.50
% slaughter wt., lbs.	7.98	2.00	4.39	0.043	3.553	2.58
% carcass wt., lbs.	18.18	4.55	12.76	2.00	3.426	4.31
Ham, lbs.	5,976	1,494**	5,970**	1.66	3.772	5.13
% slaughter wt., lbs.	5.23	1.31	3.00	0.024	2.207	2.10
% carcass wt., lbs.	13.87	3.47	8.86	1.23	3.783	5.34
Biceps femoris, lbs.	5.01	1.25**	4.75**	0.110	0.150	0.098
% slaughter wt., lbs.	3.12	0.78	1.02	0.910	1.190	1.63
% carcass wt., lbs.	4.27	1.07	2.87	1.010	0.390	0.934
Semimembranosus, lbs.	5.13	1.28**	4.80**	0.090	0.240	0.068
% slaughter wt., lbs.	3.31	0.83	1.13	0.456	1.724	1.36
% carcass wt., lbs.	3.95	0.99*	3.05*	0.321	0.579	0.341
Biceps femoris fat-free lean, lbs.	4.83	1.21*	4.25**	0.224	0.356	0.364
% slaughter wt., lbs.	2.99	0.75	0.958	0.886	1.146	0.834
% carcass wt., lbs.	4.14	1.04*	3.34*	0.156	0.644	0.321
Semimembranosus fat-free lean, lbs.	4.91	1.23**	4.63**	0.110	0.170	0.294
% slaughter wt., lbs.	3.03	0.76	1.02	0.834	1.076	0.784
% carcass wt., lbs.	4.36	1.09	2.67	0.634	1.056	0.683

* $P \leq .05$

** $P \leq .01$

TABLE XXXVIII

MEAN SQUARE VALUES AND LINEAR AND QUADRATIC RELATIONSHIPS BETWEEN WEIGHT AND DIFFERENT CARCASS MEASUREMENTS ON HAMPSHIRE PIGS

Measurements	Slaughter Weight S.S.	Slaughter Weight M.S.	Linear S.S.	Quadratic S.S.	Other S.S.	E.M.S.
Ham and loin, lbs.	14,417	3,604**	14,292**	63.46*	60.75	10.77
% slaughter wt., lbs.	43.13	10.78**	27.20**	7.79	8.13	2.49
% carcass wt., lbs.	300.79	75.20**	287.44**	0.341	13.00	4.73
Ham, lbs.	11,589	2,897**	11,563**	2.64	23.03	9.67
% slaughter wt., lbs.	35.24	8.81	23.10*	4.03	8.153	8.61
% carcass wt., lbs.	250.38	62.60**	237.14**	0.305	12.935	14.35
Biceps femoris, lbs.	7.03	1.76**	6.34**	0.361	0.329	0.075
% slaughter wt., lbs.	4.62	1.16	1.05	0.834	2.736	1.21
% carcass wt., lbs.	5.38	1.35*	3.82*	0.345	0.215	0.432
Semimembranosus, lbs.	7.08	1.77**	6.53**	0.234	0.316	0.071
% slaughter wt., lbs.	4.32	1.08	2.31	1.03	0.980	1.06
% carcass wt., lbs.	5.41	1.35*	4.51*	0.316	0.584	0.513
Biceps femoris fat-free lean, lbs.	6.97	1.74**	6.42**	0.214	0.336	0.094
% slaughter wt., lbs.	3.82	0.96	1.03	1.04	1.750	1.36
% carcass wt., lbs.	4.36	1.09**	3.96**	0.134	0.266	0.210
Semimembranosus fat-free lean, lbs.	6.41	1.60**	6.01**	0.118	0.282	0.083
% slaughter wt., lbs.	3.94	0.99	1.10	0.932	1.908	1.28
% carcass wt., lbs.	4.79	1.20*	3.72*	0.367	0.703	0.436

* $P \leq .05$

** $P \leq .01$

TABLE XXXIX

MEAN SQUARE VALUES AND LINEAR AND QUADRATIC RELATIONSHIPS BETWEEN WEIGHT AND DIFFERENT CHEMICAL COMPONENTS OF LEAN AND INDIVIDUAL MUSCLES FOR YORKSHIRE PIGS

Measurements	Slaughter Weight S.S.	Slaughter Weight M.S.	Linear S.S.	Quadratic S.S.	Other S.S.	E.M.S.
Ether-extract, percent (separable lean)	25.27	6.32	17.08	4.82	3.37	7.30
Moisture, percent (separable lean)	47.65	11.91*	35.88**	5.52	6.25	4.36
Potassium[a] (separable lean)	1.23	0.31	0.043	0.441	0.746	0.912
Ether-extract, percent (biceps femoris)	11.27	2.82	9.30*	1.15	0.820	4.46
Moisture, percent (biceps femoris)	43.99	11.00**	36.29**	5.71	1.993	2.28
Potassium (biceps femoris)	2.68	0.67	1.84	0.211	0.629	0.629
Ether-extract, percent (longissimus dorsi)	3.05	0.76	0.028	2.18	0.838	2.74
Moisture, percent (longissimus dorsi)	41.31	10.33**	23.25**	2.24	1.747	1.65
Potassium (longissimus dorsi)	5.59	1.40	3.85	0.289	1.459	2.08
Ether-extract, percent (semimembranosus)	14.72	3.68*	12.33**	0.022	0.363	1.46
Moisture, percent (semimembranosus)	46.79	11.70**	44.90**	0.717	1.166	1.36
Potassium (semimembranosus)	3.67	0.92	2.91	0.159	0.597	0.931

* $P \leq .05$

** $P \leq .01$

[a] Expressed as mg of potassium per g of ground lean sample (fat-free, dry matter basis).

TABLE XL

MEAN SQUARE VALUES AND LINEAR AND QUADRATIC RELATIONSHIPS BETWEEN WEIGHT AND DIFFERENT CHEMICAL COMPONENTS OF LEAN AND INDIVIDUAL MUSCLES FOR HAMPSHIRE PIGS

Measurements	Slaughter Weight S.S.	Slaughter Weight M.S.	Linear S.S.	Quadratic S.S.	Other S.S.	E.M.S.
Ether-extract, percent (separable lean)	181.73	45.43**	155.48**	21.69*	4.56	4.42
Moisture, percent (separable lean)	171.49	42.87**	142.93**	23.47*	5.10	10.03
Potassium[a] (separable lean)	2.40	0.60	0.136	1.043	1.220	0.713
Ether-extract, percent (biceps femoris)	43.35	10.84*	29.76*	10.64	2.947	3.82
Moisture, percent (biceps femoris)	66.56	16.64**	39.89**	17.62*	9.03	2.53
Potassium (biceps femoris)	10.95	2.74	9.18*	0.450	1.313	2.01
Ether-extract, percent (longissimus dorsi)	2.07	0.52	0.554	0.146	1.368	2.87
Moisture, percent (longissimus dorsi)	14.81	3.70	8.99*	5.23	0.590	1.97
Potassium (longissimus dorsi)	34.98	8.75**	25.77**	5.00	4.207	1.88
Ether-extract, percent (semimembranosus)	18.23	4.56**	17.46**	0.001	0.769	1.08
Moisture, percent (semimembranosus)	24.47	6.12**	21.29**	2.13	1.054	1.32
Potassium (semimembranosus)	17.75	4.44*	12.27*	3.23	2.243	1.28

* $P \leq .05$

** $P \leq .01$

[a] Expressed as mg of potassium per g of ground lean sample (fat-free, dry matter basis).

TABLE XLI

MEANS AND STANDARD ERRORS FOR CARCASS YIELDS EXPRESSED AS A PERCENTAGE OF SHRUNK LIVE WEIGHT FOR YORKSHIRE PIGS AT DIFFERENT WEIGHTS

Carcass Yields	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Fat-free lean, lbs.	37.6 ±1.50	37.1 ±1.38	37.1 ±0.62	38.1 ±1.38	36.9 ±0.89
Fat, lbs.	17.1 ±1.24	20.4 ±1.42	24.1 ±1.31	25.6 ±0.99	27.4 ±1.31
Bone, lbs.	12.6 ±0.72	10.8 ±0.18	10.8 ±0.49	10.2 ±0.26	9.6 ±0.36
Lean cuts, lbs.	42.14±1.54	42.32±0.98	42.43±0.78	43.75±1.35	42.53±1.18
Ham and loin, lbs.	33.22±1.34	34.23±0.63	36.73±0.42	37.52±0.40	37.90±0.51
Ham, lbs.	17.52±0.47	17.30±0.43	18.30±0.29	18.82±0.39	18.85±0.38
Biceps femoris, lbs.	1.19±0.043	1.10±0.081	0.97±0.038	1.11±0.075	1.12±0.043
Semimembranosus, lbs.	1.00±0.031	0.97±0.055	0.97±0.034	1.02±0.055	0.95±0.040
Biceps femoris (FFL), lbs.	0.98±0.036	0.97±0.055	0.86±0.031	0.98±0.049	0.92±0.042
Semimembranosus (FFL), lbs.	1.13±0.047	1.06±0.096	0.92±0.036	1.08±0.055	1.07±0.040

TABLE XLII

MEANS AND STANDARD ERRORS FOR CARCASS YIELDS EXPRESSED AS A PERCENTAGE OF SHRUNK LIVE WEIGHT FOR HAMPSHIRE PIGS AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
Carcass Yields	100	150	200	250	300
Fat-free lean, lbs.	38.6 ±0.80	38.5 ±0.68	35.7 ±0.71	36.0 ±0.69	33.6 ±0.70
Fat, lbs.	16.6 ±0.89	20.9 ±0.83	25.6 ±0.84	28.5 ±0.83	31.9 ±0.73
Bone, lbs.	11.9 ±0.31	10.9 ±0.30	10.0 ±0.21	9.8 ±0.22	9.2 ±0.17
Lean cuts, lbs.	43.61±0.81	44.57±0.79	41.89±0.75	42.95±0.61	39.80±0.82
Ham and loin, lbs.	33.29±0.41	35.07±0.32	36.04±0.24	37.22±0.36	37.90±0.34
Ham, lbs.	17.30±0.25	17.74±0.21	17.42±0.21	18.59±0.26	17.83±0.25
Biceps femoris, lbs.	1.12±0.030	1.13±0.031	1.04±0.039	1.08±0.028	1.09±0.029
Semimembranosus, lbs.	1.07±0.052	1.08±0.057	0.97±0.028	0.98±0.027	0.97±0.028
Biceps femoris (FFL), lbs.	1.03±0.033	1.04±0.041	0.93±0.026	0.94±0.025	0.93±0.028
Semimembranosus (FFL), lbs.	1.07±0.027	1.06±0.027	0.96±0.029	1.00±0.030	1.02±0.029

TABLE XLIII

ANALYSIS OF VARIANCE FOR ETHER-EXTRACT FOR YORKSHIRES IN A HEIRARCHAL DESIGN

Source	d.f.	Mean Square
Pen	2	285.16**
Weight Group	4	59.49
Pen * Weight Group[b]	8	75.60*
Pig (Pen Weight Group)[a]	50	29.88
Muscle	3	3,007.70**
Pen * Muscle[d]	6	10.58
Weight Group * Muscle	12	6.50
Pen * Weight Group * Muscle	24	10.05
Pig * Muscle (Pen Weight Group)[c]	45	10.46
Grab	240	0.045**
Duplicate[e]	360	0.012

* $P \leq .05$

** $P \leq .01$

[a] Pig (Pen Weight Group) - d.f., and sums of squares were pooled between breeds and this mean square value was used to test Pen and Pen * Weight Group.

[b] Pen * Weight Group M.S. was used to test Weight Group.

[c] Pig * Muscle M.S. was used to test Pen * Muscle, Weight Group * Muscle, and Pen * Weight Group * Muscle.

[d] Pen * Muscle M.S. was used to test Muscle.

[e] Duplicate M.S. was used to test Grab.

TABLE XLIV

ANALYSIS OF VARIANCE FOR ETHER-EXTRACT FOR HAMPSHIRES IN A HEIRARCHAL DESIGN

Source	d.f.	Mean Square
Pen	6	175.14**
Weight Group	4	226.82**
Pen * Weight Group[b]	24	26.65
Pig (Pen Weight Group)[a]	50	29.83
Muscle	3	9,305.42**
Pen * Muscle[d]	18	14.46
Weight Group * Muscle	12	48.06**
Pen * Weight Group * Muscle	72	9.26
Pig * Muscle (Pen Weight Group)[c]	105	10.84
Grab	560	0.047**
Duplicate[e]	840	0.029

* $P \leq .05$

** $P \leq .01$

[a] Pig (Pen Weight Group) - d.f., and sums of squares were pooled between breeds and this mean square value was used to test Pen and Pen * Weight Group.

[b] Pen * Weight Group M.S. was used to test Weight Group.

[c] Pig * Muscle M.S. was used to test Pen * Muscle, Weight Group * Muscle, and Pen * Weight Group * Muscle.

[d] Pen * Muscle M.S. was used to test Muscle.

[e] Duplicate M.S. was used to test Grab.

TABLE XLV

ANALYSIS OF VARIANCE FOR POTASSIUM OF YORKSHIRES IN A HEIRARCHAL DESIGN

Source	d.f.	Mean Square
Pen	1	0.72
Weight Group	4	12.06
Pen * Weight Group[b]	4	17.84
Pig (Pen Weight Group)[a]	30	20.59
Muscle	3	19.00**
Pen * Muscle[d]	3	2.69
Weight Group * Muscle	12	2.90
Pen * Weight Group * Muscle	12	2.23
Pig * Muscle (Pen Weight Group)[c]	30	2.97
Grab	160	0.72
Duplicate[e]	240	0.69

* $P \leq .05$

** $P \leq .01$

[a] Pig (Pen Weight Group) - d.f. and sums of squares were pooled between breeds and this mean square value was used to test Pen and Pen * Weight Group.

[b] Pen * Weight Group M.S. was used to test Weight Group.

[c] Pig * Muscle M.S. was used to test Pen * Muscle, Weight Group * Muscle, and Pen * Weight Group * Muscle.

[d] Pen * Muscle M.S. was used to test Muscle.

[e] Duplicate M.S. was used to test Grab.

TABLE XLVI

ANALYSIS OF VARIANCE FOR POTASSIUM OF HAMPSHIRES IN A HEIRARCHAL DESIGN

Source	d.f.	Mean Square
Pen	3	43.45
Weight Group	4	55.80
Pen * Weight Group[b]	12	24.95
Pig (Pen Weight Group)[a]	30	20.59
Muscle	3	28.85*
Pen * Muscle[d]	9	7.84
Weight Group * Muscle	12	10.26*
Pen * Weight Group * Muscle	36	2.89
Pig * Muscle (Pen Weight Group)[c]	60	4.59
Grab	320	0.81
Duplicate[e]	480	0.76

* $P \leq .05$

** $P \leq .01$

[a] Pig (Pen Weight Group) - d.f. and sums of squares were pooled between breeds and this mean square value was used to test Pen and Pen * Weight Group.

[b] Pen * Weight Group M.S. was used to test Weight Group.

[c] Pig * Muscle M.S. was used to test Pen * Muscle, Weight Group * Muscle, and Pen * Weight Group * Muscle.

[d] Pen * Muscle M.S. was used to test Muscle.

[e] Duplicate M.S. was used to test Grab.

TABLE XLVII

MEANS AND STANDARD ERRORS FOR POTASSIUM CONCENTRATION IN CERTAIN MUSCLES OF YORKSHIRE PIGS AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Number	4	4	4	4	4
Biceps femoris	15.44±0.38[a]	15.12±0.44[a]	14.73±0.33[a]	14.46±0.10[a]	14.64±0.27[a]
Longissimus dorsi	14.91±0.74[a]	14.50±0.60[a]	14.10±0.58[a]	13.39±0.42[a]	13.82±0.56[a]
Semimembranosus	15.61±0.45[a]	14.52±0.51[a]	14.97±0.41[a]	14.43±0.20[a]	14.25±0.18[a]

[a] Means in the same column bearing a different superscript are significantly ($P \leq .05$) different.

TABLE XLVIII

MEANS AND STANDARD ERRORS FOR POTASSIUM CONCENTRATION IN CERTAIN MUSCLES OF HAMPSHIRE PIGS AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Number	8	8	8	8	8
Biceps femoris	16.75±0.63[a]	16.46±0.40[a]	15.88±0.32[a]	15.55±0.22[a]	15.43±0.18[a]
Longissimus dorsi	17.15±0.46[a]	16.47±0.42[a]	15.43±0.29[a]	14.37±0.39[a]	15.24±0.16[a]
Semimembranosus	17.24±0.37[a]	16.39±0.35[a]	15.99±0.30[a]	15.44±0.33[a]	15.79±0.12[a]

[a] Means in the same column bearing a different superscript are significantly ($P \leq .05$) different.

TABLE XLIX

MEANS AND STANDARD ERRORS FOR ETHER-EXTRACT IN CERTAIN MUSCLES OF YORKSHIRE PIGS AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Number	6	6	6	6	6
Biceps femoris	4.61 ± 0.50^{a}	5.01 ± 1.00^{a}	6.10 ± 0.63^{a}	5.83 ± 0.99^{a}	6.16 ± 1.04^{a}
Longissimus dorsi	4.72 ± 0.60^{a}	3.57 ± 1.01^{ab}	4.29 ± 0.39^{ab}	3.87 ± 0.41^{ab}	4.63 ± 0.70^{a}
Semimembranosus	2.68 ± 0.28^{b}	2.64 ± 0.62^{b}	3.90 ± 0.36^{b}	3.69 ± 0.62^{b}	4.45 ± 0.48^{a}

[a,b] Means in the same column bearing a different superscript are significantly ($P \leq .05$) different.

TABLE L

MEANS AND STANDARD ERRORS FOR ETHER-EXTRACT IN CERTAIN MUSCLES OF HAMPSHIRE PIGS AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Number	14	14	14	14	14
Biceps femoris	5.51 ± 0.45^{a}	6.22 ± 0.29^{a}	7.32 ± 0.64^{a}	7.48 ± 0.48^{a}	7.36 ± 0.70^{a}
Longissimus dorsi	4.76 ± 0.57^{ab}	4.84 ± 0.36^{b}	5.13 ± 0.52^{b}	4.79 ± 0.42^{b}	5.13 ± 0.40^{b}
Semimembranosus	3.46 ± 0.30^{b}	3.73 ± 0.17^{b}	4.24 ± 0.33^{b}	4.46 ± 0.23^{b}	4.88 ± 0.33^{b}

[a,b] Means in the same column bearing a different superscript are significantly $(P \leq .05)$ different.

TABLE LI

AVERAGE INCREASE IN POUNDS OF FAT-FREE LEAN, FAT, AND BONE FOR EACH 50 POUND INCREASE IN SLAUGHTER WEIGHT FOR YORKSHIRE PIGS

	Slaughter Weight Groups (pounds)			
	100-150	150-200	200-250	250-300
Fat-free lean	17.1	17.6	23.4	14.7
Fat	13.0	17.0	17.3	17.5
Bone	3.3	5.1	4.5	3.3

TABLE LII

AVERAGE INCREASE IN POUNDS OF FAT-FREE LEAN, FAT, AND BONE FOR EACH 50 POUND INCREASE IN SLAUGHTER WEIGHT FOR HAMPSHIRE PIGS

	Slaughter Weight Groups (pounds)			
	100-150	150-200	200-250	250-300
Fat-free lean	17.7	13.3	19.0	11.3
Fat	14.0	19.5	20.2	25.1
Bone	4.0	3.7	4.4	3.3

TABLE LIII

THE PERCENT VARIATION ACCOUNTED FOR IN PERCENT ETHER-EXTRACT FOR THE SAMPLING PROCEDURE OF THE SEPARABLE LEAN FOR YORKSHIRE PIGS

	Slaughter Weight Groups (pounds)				
Percent Variation Accounted For By	100[a]	150[a]	200[a]	250[a]	300[a]
Animal	99.24	99.71	95.08	98.56	99.75
Grab	0.44	0.25	3.29	0.89	0.03
Determination	0.32	0.04	1.63	0.55	0.22

[a] Degrees of freedom--animal 5, grab 12, determination 18.

TABLE LIV

THE PERCENT VARIATION ACCOUNTED FOR IN PERCENT ETHER-EXTRACT FOR THE SAMPLING PROCEDURE OF THE SEPARABLE LEAN FOR HAMPSHIRE PIGS

	Slaughter Weight Groups (pounds)				
Percent Variation Accounted For By	100[a]	150[a]	200[a]	250[a]	300[a]
Animal	99.75	98.74	99.24	99.41	98.39
Grab	0.07	0.34	0.29	0.12	0.41
Determination	0.18	0.92	0.47	0.47	1.20

[a] Degrees of freedom--animal 13, grab 28, determination 42.

TABLE LV

THE PERCENT VARIATION ACCOUNTED FOR IN POTASSIUM FOR THE SAMPLING PROCEDURE OF THE SEPARABLE LEAN FOR YORKSHIRE PIGS

	Slaughter Weight Groups (pounds)				
Percent Variation Accounted For By	100[a]	150[a]	200[a]	250[a]	300[a]
Animal	5.67	89.74	43.55	52.25	4.30
Grab	0.00	0.00	0.00	17.26	2.90
Determination	94.33	10.26	56.45	30.49	92.80

[a] Degrees of freedom--animal 3, grab 8, determination 12.

TABLE LVI

THE PERCENT VARIATION ACCOUNTED FOR IN POTASSIUM FOR THE SAMPLING PROCEDURE OF THE SEPARABLE LEAN FOR HAMPSHIRE PIGS

	Slaughter Weight Groups (pounds)				
Percent Variation Accounted For By	100[a]	150[a]	200[a]	250[a]	300[a]
Animal	66.78	12.27	37.69	41.93	20.75
Grab	0.00	8.52	0.00	10.90	0.00
Determination	33.22	79.21	62.31	47.17	79.25

[a] Degrees of freedom--animal 7, grab 16, determination 24.

TABLE LVII

AVERAGE INCREASE IN POUNDS AND AS A PERCENTAGE OF LIVE WEIGHT OF THE BICEPS FEMORIS AND SEMIMEMBRANOSUS FOR EACH 50 POUND INCREASE IN SLAUGHTER WEIGHT OF YORKSHIRE PIGS

	Slaughter Weight Groups (pounds)			
	100-150	150-200	200-250	250-300
Biceps femoris				
Pounds	0.43	0.27	1.22	0.50
% Slaughter wt.	0.29	0.14	0.49	0.17
Semimembranosus				
Pounds	0.43	0.25	0.87	0.30
% Slaughter wt.	0.29	0.13	0.35	0.10

TABLE LVIII

AVERAGE INCREASE IN POUNDS AND AS A PERCENTAGE OF LIVE WEIGHT OF THE BICEPS FEMORIS AND SEMIMEMBRANOSUS FOR EACH 50 POUND INCREASE IN SLAUGHTER WEIGHT OF HAMPSHIRE PIGS

	Slaughter Weight Groups (pounds)			
	100-150	150-200	200-250	250-300
Biceps femoris				
Pounds	0.53	0.36	0.63	0.60
% Slaughter wt.	0.35	0.18	0.25	0.20
Semimembranosus				
Pounds	0.52	0.31	0.52	0.47
% Slaughter wt.	0.35	0.16	0.21	0.16

TABLE LIX

MEAN K^{40} COUNTS PER MINUTE PER POUND OF FAT-FREE LEAN FOR YORKSHIRE AND HAMPSHIRE PIGS AT DIFFERENT WEIGHTS

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Yorkshires					
Number	6	6	6	6	6
K^{40} CPM per pound of fat-free lean	95.82	82.74	72.26	62.51	58.61
Hampshires					
Number	14	14	14	14	14
K^{40} CPM per pound of fat-free lean	95.59	85.89	73.89	67.83	61.40

VITA

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Doctor of Philosophy

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