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# Use of $K^{40}$ Net Count as a Monitor of Body Composition Changes in Growing and Fattening Swine

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## Story in Brief

This research was initiated to investigate the possibility of using the $K^{40}$ technique to monitor the body composition changes in muscling in swine at different ages and weights. A new detector arrangement was utilized in this series of whole-body counting studies with swine in an attempt to improve $K^{40}$ counting efficiency over live weights ranging from 100 to 300 pounds. The new arrangement of detectors provided for more flexibility in the $K^{40}$ counting of live pigs over a range of live weights than has been possible in the earlier phases of this work using plastic scintillation detectors.

One hundred barrows (70 Hampshires and 30 Yorkshires) were used in this study that involved ten replications of ten pigs each. Each replication consisted of ten feeder pigs that were randomly allotted to slaughter weight groups of 100, 150, 200, 250 and 300 pounds and placed on a growing-fattening ration. From each replication, two pigs were randomly assigned to each slaughter weight group, making a total of 20 pigs for each of five slaughter weights. Each pig was taken off feed and $K^{40}$ evaluated at each weight interval, irrespective of final slaughter weight, and then was placed back on feed until it reached the pre-determined slaughter weight. The pigs were slaughtered at their pre-determined slaughter weight immediately following live $K^{40}$ evaluation.

Ether-extract and potassium analyses were conducted on ground lean samples of the right carcass halves and total pounds of fat-free lean were determined by difference. In addition, the biceps femoris, semimembranosus, and longissimus dorsi muscles were removed from the carcass and analyzed chemically for potassium and ether-extract in an effort to more clearly characterize the relation of potassium concentration in certain muscles to total muscle potassium.

A detailed statistical analysis of the data is in progress. Mean values involving certain of the data along with trends which these data suggest are presented. A full report of the findings will be made after the statistical analysis is completed.

## Introduction

The increased emphasis placed on muscling in meat animals in recent years has brought about a greater need for more accurate means of evaluating live animals with respect to fat and muscle development. Animals of similar ages and market weights have been shown to differ greatly in the lean-to-fat ratio in their carcasses. These differences have been observed not only within breeds but also within family lines as well as within sire progeny groups. Since most carcass traits are moderately to highly heritable, effective tools for meat animal appraisal are needed to estimate more accurately the body composition of animals for breeding purposes. One such non-destructive method developed during recent times for the evaluation of composition in live 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 gamma radiation arising from the element potassium 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. 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 potassium is radioactive and emits radiation energy which can be measured.

Previous research at the Oklahoma Agricultural Experiment Station has been conducted with animals that were as uniform in age, breed, weight and condition as possible in order to subject the O.S.U. $K^{40}$ whole-body counter to critical tests of repeatability and in estimating differences in muscling among meat animals. Results from several studies dealing with the association between live net $K^{40}$ count and pounds of fat-free lean in swine have led to the development of prediction equations which are currently used to evaluate the muscle content of 220-240 pound hogs.

Questions have arisen concerning the capability of the $K^{40}$ counter to predict muscling in swine of younger ages and lighter weights. If superior muscled animals could be identified at an early age, considerable savings in time and expense could be achieved by the swine breeder and feeder.

With these ideas as a background, research was designed to study the use of $K^{40}$ net count as a monitor of body composition changes in growing and fattening swine.

## Materials and Methods

One hundred market barrows (70 Hampshire and 30 Yorkshires) were evaluated by the $K^{40}$ whole-body counter (using plastic scintillation detectors) beginning in March, 1972 and ending in October, 1973. A new detector arrangement was used in counting the live animals in an attempt to improve $K^{40}$ counting efficiency over a range of live weights (100 to 300 pounds). A method was devised for positioning the barrows as close to the detector system as possible, since earlier work had shown this consideration to be an important one in $K^{40}$ evaluation.

Ten replications, each consisting of ten feeder pigs, were randomly assigned to slaughter weight groups of 100, 150, 200, 250 and 300 pounds and placed on a growing-fattening ration. 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 1.

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. The pigs were then probed at the first rib, last rib and last lumbar verte-

**Table 1. Experimental Design**

| | Slaughter Weight Groups (pounds) | | | | |
|---|---|---|---|---|---|
| Replication | 100 | 150 | 200 | 250 | 300 |
| I | 2[1] | 2 | 2 | 2 | 2 |
| – | – | – | – | – | – |
| X | 2 | 2 | 2 | 2 | 2 |
| Total | 20[2] | 20 | 20 | 20 | 20 |

[1] Number of animals per replication per weight group.
[2] Total number of animals per weight group.

bra with a Ducan Lean Meter and $K^{40}$ counted in a randomized order. Each barrow was evaluated twice on the same day by the $K^{40}$ whole body counter using five 1-minute "fore-ground" counts, five 1-minute live animal counts and five 1-minute "back-ground" counts from which "Net $K^{40}$ Count" data were obtained.

Those barrows designated at the beginning of the experiment to be slaughtered at a particular weight were transported to the O.S.U. Meat Laboratory for slaughter and carcass composition evaluation. Carcass measurements obtained included length, average backfat thickness, loin eye area, weight of ham, loin and shoulder, weight of total fat trim, bone weight and weight of boneless closely trimmed lean from the right carcass half. In addition, three muscles (biceps femoris, longissimus dorsi, and semimembranosus) were removed from the right carcass halves and individually weighed for purposes of observing some possible trends in muscle development as related to age and weight.

Chemical analyses for ether-extract were conducted in triplicate on samples representing the boneless closely trimmed muscle mass from the right half of each carcass as well as samples from the three individual muscles described above. Ether extraction on samples from all 100 barrows was determined by a standard A.O.A.C. method. 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. 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 representative samples were taken from ground lean of the right carcass halves and from the three specified muscles. The potassium analysis involved a wet ashing procedure, and the use of a Perkin-Elmer Model 401 Atomic Absorption Spectrophotometer to quantitate the potassium content of the samples.

## Results and Discussion

Complete statistical analyses of the data are currently in progress. In this report, mean values of certain of the data are presented and trends in these means discussed. The means of slaughter weight, fat-free lean and $K^{40}$ net count are shown in Table 2.

As slaughter weight increased, pounds of fat-free lean also increased (Table 2). The graphic plot of pounds of fat-free lean and slaughter weight groups is presented in Figure 1. This plot suggests a near linear relationship between pounds of fat-free lean in the carcass and slaughter weight. The slope of the graphic line representing pounds of fat-free lean at different weight groups appears to be nearly constant from 100 to 300

Table 2. Means of Live and Carcass Measurements From Pigs Slaughtered at Various Weights

| | Slaughter Weight Groups (pounds) | | | | |
|---|---|---|---|---|---|
| | 100 | 150 | 200 | 250 | 300 |
| Number | 20 | 20 | 20 | 20 | 20 |
| Slaughter Wt., lbs. | 101 | 148 | 197 | 249 | 300 |
| Fat-Free Lean, lbs. | 38.9 | 57.4 | 70.9 | 90.6 | 103.7 |
| $K^{40}$ Net Count | 3715 | 4789 | 5207 | 6037 | 6268 |

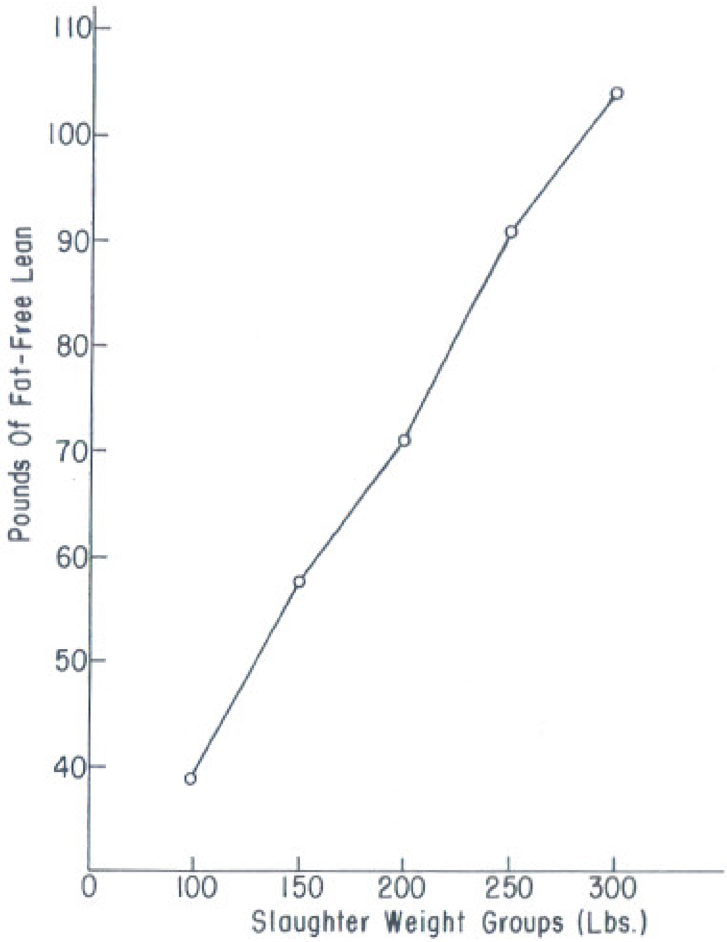


Figure 1. Mean pounds of fat-free lean from pigs representing five different weight groups.

pounds. This would indicate that the hogs used in this study were still growing and developing muscle (rather than depositing fat) up to and including 300 pounds live weight. This observation conflicts with earlier swine research where a decline of muscle development and an increase in fat deposition has been shown to occur between 200 and 250 pounds live weight. Large framed, growthy, heavily muscled pigs obtained from the University herds were used in this study and may explain the near linear response for fat-free lean from 100 to 300 pounds observed in Figure 1. The stage of most rapid muscular development as a percentage of live weight (12.4 percent increase) was found to be from 100 to 150 pounds, while the least muscular development (4.3 percent increase) occurred between the weights of 250 and 300 pounds.

As slaughter weight increased, net $K^{40}$ count per minute increased. The relationship between net $K^{40}$ count and slaughter weight group is more clearly illustrated in Figure 2, where the solid line presents the plot of data for the pigs that were slaughtered at each weight, while the dotted line presents the plot of data for all pigs that were $K^{40}$ evaluated at these weights, including those not slaughtered. The plots indicate that pigs slaughtered from each of the different groups appear to have been quite representative of all the pigs $K^{40}$ evaluated at that weight since average net $K^{40}$ count was similar. The increase in net $K^{40}$ count associated with an increase in live weight is shown in Figure 2. It appears that the most rapid increase in net $K^{40}$ count per minute occurred between the 100 and 150 pound weights, while the smallest increment in $K^{40}$ count was between the 250 and 300 pound weights. This observation is in agreement with other research which has indicated that muscle growth occurs more rapidly in youthful animals and at a slower rate in heavier, more mature animals. The small increase in net $K^{40}$ count from 250 to 300 pounds may be due to the possible "shielding" effect of fat against the transmission of radiation energy from whole-body potassium. Consequently, there is the possibility that as hogs are carried to heavier weights and become fatter, less radiation from potassium may penetrate the fat layers resulting in poorer relationships between count and muscling in heavier hogs. Another reason for the small increase in net $K^{40}$ count in the heavier weight hogs may be attributed to the self-absorption of gamma rays emitted from the muscle in the animals. The larger the animal, the greater 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 relationship between average net $K^{40}$ count per minute and pounds of fat-free lean is illustrated in Figure 3. The width of each bar is representative of the standard deviation of the mean fat-free lean values for each weight group shown in Table 2. Figure 3 suggests a near

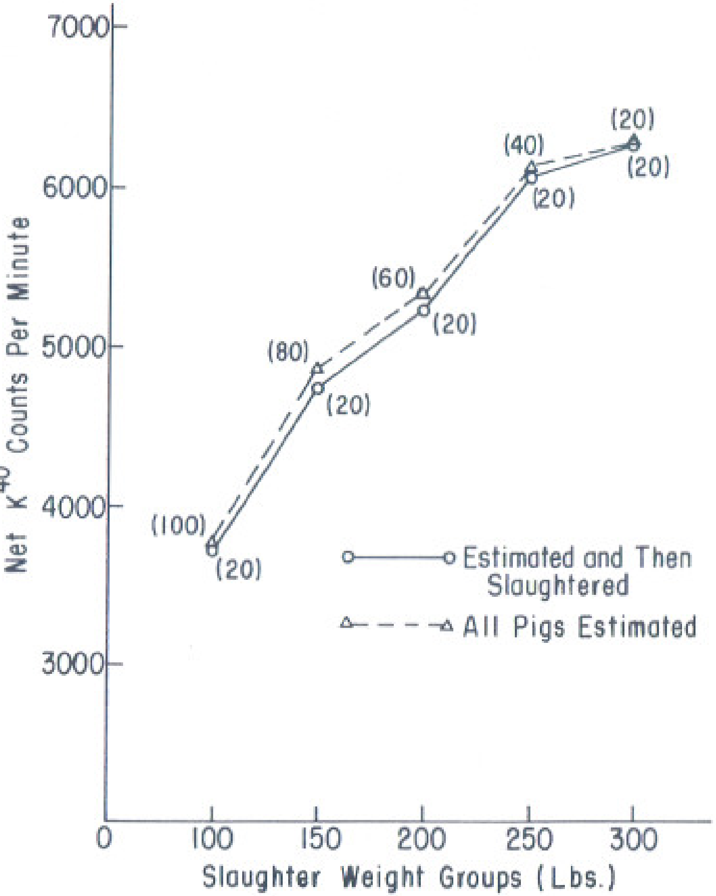


**Figure 2.** **Mean counts per minute for pigs $K^{40}$ evaluated and slaughtered and for all pigs $K^{40}$ evaluated at five live weights.**

linear relationship between the average net $K^{40}$ count per minute and pounds of fat-free lean from 100 pounds live weight through all weight groups including 250 pounds. The means of the data suggest that net $K^{40}$ count could be used as a predictor of leanness in hogs ranging from 100 to 300 pounds. After prediction equations are developed, pounds of fat-free lean can quite likely be estimated from the net $K^{40}$ count of live hogs weighing between 100 and 300 pounds, but with a precision that must await further statistical analysis. Net $K^{40}$ count per pound of fat-

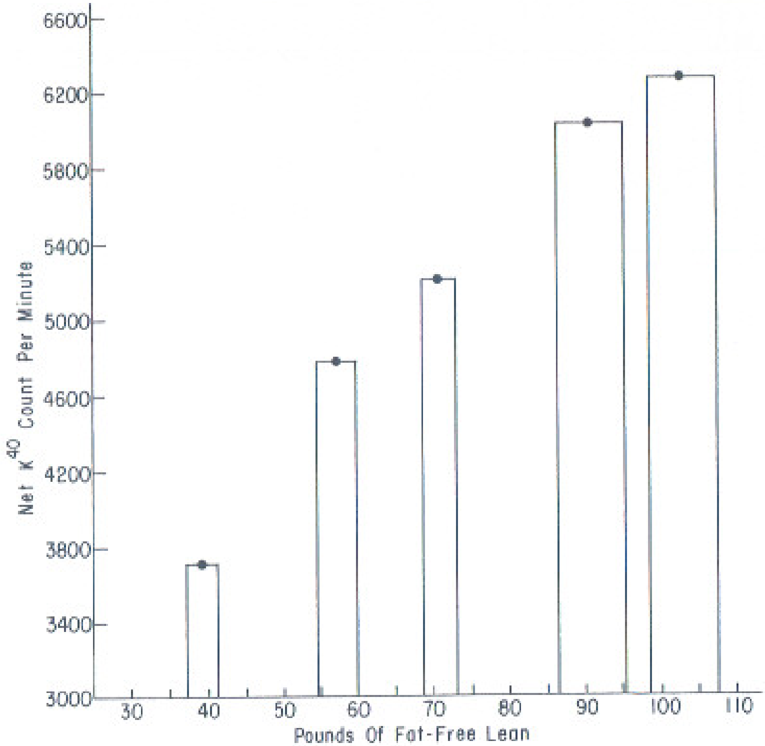


**Figure 3. Mean live $K^{40}$ counts per minute and pounds of fat-free lean at each weight.**

free lean for 100, 150, 200, 250 and 300 pound weight groups were 95.5, 83.4, 73.4, 66.6 and 60.5, respectively. These values suggest that net $K^{40}$ count per pound of fat-free lean decreases as slaughter weight increases, thus indicating that increased external fat may hinder the relationship between $K^{40}$ count and muscling in heavier hogs as discussed previously.

Table 3 presents the means for potassium concentration (expressed as milligrams of potassium per gram of muscle on a fat-free, dry matter basis) found in the total muscle of the right sides of each carcass and in the three individual muscles from pigs in the first six replications. The relationship between chemical potassium (for total muscle and the three individual muscles) and the five slaughter weight groups is presented in a plot of mean values in Figure 4. The potassium content in all three muscles studied tended to decrease as slaughter weight increased, except between 250 and 300 pounds live weight where there was a slight in-

Table 3. Means of Potassium Concentration in Certain Muscle Components

| | Slaughter Weight Groups (pounds) | | | | |
|---|---|---|---|---|---|
| | 100 | 150 | 200 | 250 | 300 |
| Number | 12 | 12 | 12 | 12 | 12 |
| Total Muscle | 14.9[1] | 14.9 | 15.2 | 15.1 | 14.7 |
| Longissimus dorsi | 16.4 | 15.8 | 15.0 | 14.2 | 14.8 |
| Biceps femoris | 16.3 | 16.0 | 15.5 | 15.3 | 15.2 |
| Semimembranosus | 16.7 | 15.8 | 15.7 | 15.1 | 15.3 |

[1] Values expressed as mg. of potassium per gram of muscle on a fat-free, dry matter basis.

crease in the potassium concentration in the longissimus dorsi and semimembranosus muscles. The graphic plot representing total muscle potassium presents no marked change with respect to increased weight as did the three individual muscles although a slight decrease in chemical occurred in the 250 to 300 pound weight groups. Generally, the potassium concentration of "total muscle" was lower than those concentrations of the three individual muscles. This observation indicates that other muscles in swine must have had lower concentrations of potassium than those muscles involved in this study. All muscles are composed of red and white fibers, and the ratio of these fibers in a muscle establish many of its characteristics and functions. Researchers have reported that muscles such as the three used in this study have a greater percentage of white fibers than red fibers. Furthermore, researchers have also established that white muscle fibers tend to have more potassium than red fibers, which may explain the lower potassium concentrations for total muscle presented in Figure 4.

Some researchers have reported differences in the potassium concentration among different muscles in swine. Differences in potassium concentration between muscles were observed in this work when expressed on a fat-free dry matter basis; however, these differences were relatively small. Of the three muscles, the longissimus dorsi tended to have the lowest concentration of potassium in muscle tissue at any slaughter weight group; however, the greatest difference in potassium concentration means between muscles at any weight group was 1.1 milligrams of potassium per gram of fat-free, dry matter tissue. These results indicate that the potassium concentrations of the three muscles were relatively similar at a particular slaughter weight.

In conclusion, these results suggest that net $K^{40}$ count on live pigs may be a useful aid in selecting for muscling in swine at weights less

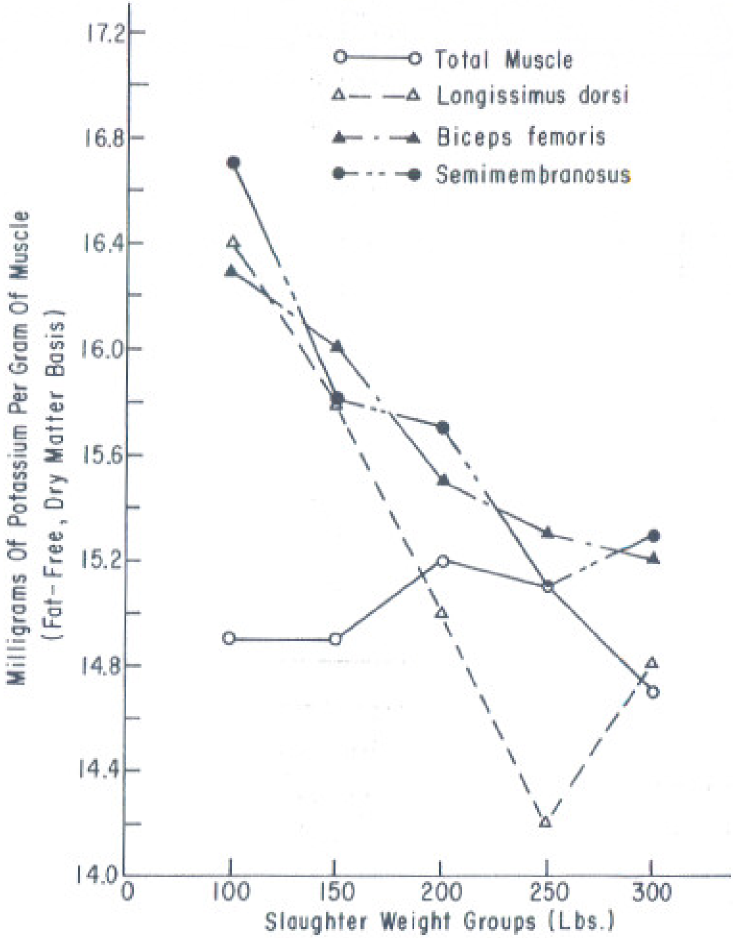


**Figure 4. Muscle potassium concentration in total muscle, longissimus dorsi, biceps femoris and semimembranosus at five different slaughter weights.**

than 220-240 pounds. The mean values suggest that a near linear relationship exists between net $K^{40}$ count and fat-free lean in hogs weighing between 100 and 250 pounds. There may be a less meaningful relationship between values appearing in a prediction equation for 300 pound hogs than for those of the four lighter weights.