ewes (194). Table 4 presents combined lamb production over the two seasons. The 198 crossbred ewes produced 410 lambs or an average of 2.07 lambs per ewe; whereas, the Dorset ewes produced 1.77 lambs per ewe and the Rambouillet ewes produced 1.73 lambs per head. Although crossbred ewes tended to have an advantage in number of lambs produced, it is believed that none of the three breeds performed up to the potential of this management program.

Table 4. Lambing Rate Under a Twice-Yearly Lambing Program.

Breed group[1]	Spring and Fall Combined D	D x R	R
No. of ewes	170	198	195
No. of lambs born	301	410	338
Flock lambing rate[2]	1.77	2.07	1.73

[1] D=Dorset, D x R=Dorset x Rambouillet, R=Rambouillet
[2] Lambs born per ewe in the flock per year within breed

The Association Between Potassium^{40} Measurement and Measures of Leanness in Swine

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Story in Brief

Potassium^{40} gamma radiation measurements were made in 1968 on fifty-three Yorkshire barrows representing five weight groups: 100, 150, 200, 250 and 300 pounds. Each pig was taken off feed and "counted" at each weight interval, irrespective of final slaughter weight, and was placed back on feed until it reached the predetermined slaughter weight. The pigs were slaughtered at their pre-determined slaughter weight immediately following live counting. The carcasses were counted and then cut into standard wholesale cuts; the right side was separated into lean, fat, and bone.

Correlation coefficients between first and second K^{40} counts were determined on the live animals and the carcasses to determine how well counts taken at different times agreed. Correlations between first and second carcass K^{40} counts were in closer agreement than those obtained

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for the live animal. From studies designed to find out how important length of counting time may be, there was essentially no difference between 10, 20, and 30 minute counting times for the live animals.

Correlations between K^{40} counts on live hogs, and pounds of fat-free lean and percent fat-free lean increased as live weight increased. This is interpreted to mean that the counts predicted the fat-free lean in the heavier weight hogs better than in the lighter weight hogs. The higher correlations for the heavier weights suggested that the procedure was more reliable than in the lighter weights. Similar trends held true for correlations among K^{40} counts on live hogs and lean cuts through the 250 pound weight group. Correlations between carcass K^{40} counts and lean cuts or fat-free lean followed basically the same trend as for the live animal—being higher in the heavier weights and lower in the lighter weights.

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. Through their buying practices, consumers have expressed a strong preference for meatier, heavier muscled retail cuts of meat with a minimum of trimmable fat. Animals of similar ages and market weights have been shown to differ greatly in the lean-to-fat ratio in their carcasses. These differences are observed not only within breeds but also within family lines as well as within sire progency. Since most carcass traits are moderately to highly heritable, more effective tools than are now available for meat animal appraisal are needed to estimate more accurately the body composition of animals for breeding purposes, as well as for slaughter.

These studies involved the use of a new concept in live animal appraisal, the whole-body K^{40} counter.

Principle of the K^{40} Counter

This method makes use of two basic principles:

(1) Most of the potassium in the body of a live animal is found in the muscle.

(2) Potassium contains a fixed proportion of naturally occurring radioactive atoms (called K^{40}, hence the name) which give off very small amounts of gamma radiation which may be measured.

In view of these principles, if K^{40} can be measured accurately, it follows that the amount of K^{40} present in a substance should become useful as a predictor of total potassium. Total body potassium then, may, in turn become useful as a predictor of total lean (muscle) in the animal since much of the potassium in an animal is found in the muscle. The instrument is designed to measure the K^{40} gamma-ray emission from the live animal. The gamma-rays emitted by K^{40} enter a "detector" and upon entry produce very minute bursts of light (scintillations). These scintillations are fed into a light sensing mechanism, the photo-multipler tube, which converts the light energy into amplified electrical signals that can be counted electronically.

Methods and Materials

Fifty-three Yorkshire barrows averaging 62 pounds were randomly alloted by slaughter weight groups — 100, 150, 200, 250, or 300 pounds. Each pig was taken off feed and "counted" at each weight interval, irrespective of final slaughter weight and was placed back on feed until it reached the pre-determined slaughter weight. The pigs were self-fed a milo-soybean meal ration containing 16 percent protein.

In preparation for counting, feed and water were removed from the pigs 36 hours prior to counting and they were thoroughly washed to remove possible potassium containing foreign materials. They were then placed in the counter in a suitable restraining crate allowing for comparable positioning of the animal in the counter among readings. The net K^{40} count for each animal was obtained in the following manner: two 10-minute background counts (to determine environmental radiation) were obtained for each animal by measuring the background K^{40} activity of the empty counter, one prior to, and one immediately following the 10-minute counting period for the animal. The average of the two background measurements was subtracted from total count (animal count + environmental gamma radiation) to obtain net K^{40} count for each animal at each counting period. This total count was converted to counts per minute, which was used in the analysis of the data. This counting procedure was repeated for each animal with an interval between the first and second counting of not less than one hour nor more than four hours.

Ten, 20, and 30 minute counting periods were used to determine the possible influence of length of counting time on repeatability of K^{40} measurement on the same pig the same day. As animals reached the predetermined slaughter weight, they were counted and slaughtered on the same day.

At the time of slaughter, the unsplit carcasses were mounted on a carcass rack in such a way as to simulate the standing position of the live pig. This was done in order to study possible effects and interrelationships of "dress-off" items on net K^{40} count. The counting procedure used for the carcasses was the same as that for the live animal—obtaining a 10-minute net count. The right side of each carcass was then separated into standard trimmed wholesale cuts following the procedure described by the American Meat Science Association. Weights of all cuts as well as total separable lean, fat and bone were obtained.

The total separable lean mass from the right side of each carcass was ground once through a 3/8" meat grinding plate and thoroughly mixed. The lean mass was then ground and mixed in a combination meat mixer-grinder through a 1/8" plate. As the mass came from the mixer-grinder, two sets of four grab samples each were randomly taken and placed in airtight sample jars for storage and subsequent proximate chemical analysis. These analyses included moisture, ether extract (fat), protein, and ash determinations. Percent fat-free lean in the carcass (and live animal) was determined by subtracting the ether extract from total separable lean.

The data were analyzed to determine (1) the degree to which the K^{40} counter repeated itself and (2) the association between net counts per minute and pounds of lean cuts (trimmed ham, loin and shoulder) and fat-free lean; and percent lean cuts and fat-free lean, both live and in the carcass.

Results and Discussion

Correlation

In order for any method or tool to be of value in a research effort, it must first of all be repeatable. The term *repeatable* means that two independent counts taken on the same animal on the same day are in close agreement. Studies were made to determine the degree to which this instrument would repeat itself. To accomplish this, it became necessary to calculate the degree of association between variables under investigation. For example, coefficients were calculated to express the association between two K^{40} counts on the same animal at different times on the same day and which became important criteria for measuring the dependability of a procedure.

Correlation coefficients range from —1.0 to +1.0. A high positive correlation would mean strong agreement between two readings. A correlation near zero would mean little agreement and unreliability in the procedure.

Live Animal Studies

The correlation coefficients between first and second live K^{40} counts for three different lengths of counting time (10, 20, and 30 minutes) and for five different weight groups are presented in Table 1. The correlation coefficients between the two 10 minute counting periods ranged from +.61 to +.94. These correlations were all significant ($P < .01$). These positive coefficients indicate that there was fair to good agreement between the two readings and thus the instrument was found to be repeating itself fairly well.

There was a trend for correlations to be lowest in the lighter weights and highest in the heavier weights. The correlations for the 20 and 30 minute counting periods followed the same general trend with a range of +.44 to +.90 for the 20 minute period and +.53 to +.90 for the 30 minute period. These data indicate that increasing the counting periods to 20 and 30 minutes did not increase the agreement between first and second live counts. Therefore, the 10 minutes counting period was used in the analysis of the data when correlations were obtained between count and measures of leanness.

Table 2 presents the correlation coefficients between first and second live K^{40} counts and the average of the two live counts for each weight group taken on the same day with pounds of lean cuts and fat-free lean and the percent of lean cuts and fat-free lean. The correlations obtained for the 100 pound weight group between count and pounds of lean cuts ranged from —.37 to +.07 and between count and percent lean cuts ranged from —.08 to +.41. When count and pounds of fat-free lean and count and percent fat-free lean were considered, the range was —.05 to 0 and +.24 to +.26 respectively. These correlations proved to be low and non-significant, meaning that there was little agreement between count and lean cuts expressed as pounds or as percent.

The 150 pound weight group showed basically the same trend. The range of correlations between count and lean cuts and count and fat-free lean was +.18 to +.47 and —.18 to +.07, respectively. The negative correlations obtained in the 100 and 150 pound weight groups show a

Table 1. Correlation Coefficients Between First and Second Live K^{40} Counts Per Minute

[Length of Counting Time (Minutes)]

Group	Ave. Live Wt.	10 N	10 r	20 N	20 r	30 N	30 r
1	103	(49)	.72**	(23)	.57**	(24)	.66**
2	151	(40)	.61**	(18)	.44*	(18)	.53*
3	199	(32)	.77**	(15)	.85**	(15)	.86**
4	250	(22)	.76**	(10)	.90**	(10)	.90**
5	296	(9)	.94**				

N = number of animals
r = correlation coefficient
* ($P < .05$)
** ($P < .01$)

Table 2. Correlation Coefficients Between K^{40} Live Counts Per Minute and Measures of Leanness

[Weight Group at Slaughter (Pounds[1])]

Measures of Leanness	K^{40} Counts	100		150		200		250		300	
		Lbs.	%	Lbs.	%	Lbs.	%	Lbs.	%	Lbs.	%
Lean Cuts	First	—.37	—.08	.47	.43	.38	.96**	.91**	.83**	.48	.52
	Second	.07	.41	.25	.18	.52	.49	.78**	.81**	.72*	.71*
	Average	—.20	.16	.39	.33	.48	.45	.88**	.86**	.61	.63
Fat-Free Lean	First	—.04	.24	.07	.05	.62**	.58	.92**	.84**	.82**	.71**
	Second	0	.26	—.14	—.18	.56	.52	.72*	.74**	.83**	.79*
	Average	—.05	.24	—.04	—.07	.62*	.58	.85**	.83**	.84**	.82**

[1] Eleven animals in all weight groups except 300 pound, (with 9).
* ($P < .01$)
** ($P < .05$)

reverse order agreement; as count went up, lean cuts and fat-free lean went down; and thus in this case, the method proved to be unreliable.

The correlations obtained between count and measures of leanness for the 200 pound weight group were higher than in the case of the lighter weight groups discussed above. The correlation between count and lean cuts and count and fat-free lean ranged from +.38 to +.96 and +.52 to +.62, respectively. Although there were some significant correlations in this group, there still was a low agreement between count and lean cuts or count and fat-free lean for this weight group.

The correlations for the 250 pound weight group were substantially higher than those previously discussed for the lighter weights. These correlations were all significant ($P < .05$) and most were highly significant ($P < .01$). The range in correlations for this group was +.78 to +.91 between count and lean cuts and +.72 to +.92 between count and fat-free lean. These relationships indicate that the live K^{40} counts per minute were highly associated with pounds and percent lean cuts as well as pounds and percent fat-free lean. In this case the counter proved to be rather precise as a predictor of leanness. Similarly, live K^{40} counts per minute were found to be significantly associated with pounds and percent fat-free lean in the 300 pound weight group with a range of +.71 to +.84 which were all statistically significant ($P < .05$), also indicating close agreement between counts and measures of leanness. Correlations obtained between count and lean cuts were not as high, for this group, as those for count and fat-free lean, with only two (+.72 and +.71) being significant ($P < .05$).

There was a trend toward higher correlations between K^{40} count and both pounds and percent of fat-free lean with increase in live weight. When K^{40} count and pounds or percent lean cuts were correlated, a similar trend was noticed through the 250 pound weight group. Correlations between count and lean cuts for the 300 pound weight group, however, were lower than in the 250 pound group. There is no explanation for the apparent decrease in accuracy considering these variables in this weight group.

Carcass Studies

Table 3 presents the correlation coefficients for the first and second carcass counts for the respective weight groups. As with the live animal, the counting period was for 10 minutes. Correlations between counting times in all weight groups were found to be significant (P < .01 and ranged from +.88 to +.96. This is interpreted to mean that the readings from the instrument from one count to another on the same day were in good agreement. Between-count correlations are expected to be higher for carcasses than for the live animals because the carcasses were held firmly in place and at a fixed distance from the detectors, and the counts were not influenced by inedible offal such as hair, gastro-intestinal tract and contents.

The data presented in Table 4 indicates the same general trend as was found for the live animals; namley, lower correlations in the lighter weights and higher correlations in the heavier weights. The correlations

Table 3. Correlation Coefficients Between First and Second Carcass K^{40} Counts Per Minute[1]

Group	Carcass Weight (lb.)	Number of Carcasses	Correlation Coefficients
1	71	11	.91**
2	108	11	.88**
3	146	11	.92**
4	187	11	.89**
5	224	9	.96**

** (P < .01)

[1] 10 minute counting period

Table 4. Correlation Coefficients Between K^{40} Carcass Counts per Minute and Measures of Leanness (Pounds)

[Weight Groups at Slaughter (Pounds)]

K^{40} Counts Per Minute	100 Lean Cuts	100 Fat-Free Lean	150 Lean Cuts	150 Fat-Free Lean	200 Lean Cuts	200 Fat-Free Lean	250 Lean Cuts	250 Fat-Free Lean	300 Lean Cuts	300 Fat-Free Lean
First	.25	.14	.74*	.40	.26	.69*	.60	.60	.73*	.80**
Second	.19	.17	.50	.24	.31	.74*	.70*	.72*	.81**	.85**
Average	.22	.16	.60	.33	.29	.73*	.66*	.67*	.78*	.83**

* (P < .01)

** (P < .05)

for the 100 pound weight group ranged from +.14 to +.25 between carcass K^{40} count and pounds of lean cuts and fat-free lean. These correlations were low and non-significant. The correlations between carcass K^{40} count and pounds of lean cuts or fat-free lean for the 150 pound weight group were also non-significant with the exception of the one +.74 between first count and pounds of lean cuts. In the 200 pound weight group, correlations between carcass K^{40} count and pounds of fat-free lean were all statistically significant ($P < .05$) with a range of +.69 to +.73. When count was correlated with pounds of lean cuts none of the three was significant.

In the 250 pound weight group, all correlations were significant ($P < .05$) with the exception of the correlation between first count and pounds of lean cuts or fat-free lean. The range for this group was from +.60 to +.72. There was a substantial increase in the correlations for the 300 pound group over those previously discussed for the lighter weight groups. The correlation between count and lean cuts and count and fat-free lean was from +.73 to +.85, which were all significant ($P < .05$) and most were highly significant ($P < .01$). This suggests that there was good agreement with both K^{40} count and pounds of lean cuts as well as K^{40} count and pounds of fat-free lean.