# Revised Approaches to Estimate Lean of Pork Carcasses of Known Age or Days on Test

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**Keywords**
Pork Carcass, Composition, Live- Carcass Interrelationships

**Disciplines**
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# REVISED APPROACHES TO ESTIMATE LEAN OF PORK CARCASSES OF KNOWN AGE OR DAYS ON TEST[1,2]

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#### Summary

Carcass measurements for 185 market hogs representing two sexes and four body types, slaughtered at 91 to 132 kg, were examined as predictors of carcass composition. Dependent variables included weight of fat-standardized lean (FSL), percentage FSL in the standardized side, weight of FSL gained/day on test, and weight of FSL produced/day of age. The greatest degree of predictive accuracy in each equation occurred when longissimus muscle area and fat depth at the three-fourths location at the 10th rib were included as independent variables. Other important variables were hot carcass weight in the three equations predicting weight for FSL, age in the equation for FSL produced/ day of age, and initial weight on test and days on test for the prediction of FSL gained/day on test. Less accuracy was found when other backfat thickness measurements or subjective scores of muscling or fatness were used as independent variables.

(Key Words: Pork Carcass, Composition, Live-Carcass Interrelationships.)

#### Introduction

The evaluation of hogs to determine the efficency of growth of lean pork requires both reliable production information and an accurate, standard and simple assessment of composition (proportion and quantities of fat-standardized muscle). Presently, hogs are evaluated in swine improvement programs (Hubbard, 1981) and contests (NPPC, 1976) on the basis of weight of lean in the carcass and days to produce 39 kg of muscle. The data from which these equations were generated (Fahey et al., 1977) consisted of a small sample (N=41) of barrow carcasses possessing minimal variations in fatness and weight, having unknown production information and representing a population of carcasses typical of those exhibited in carcass competitions. However, Edwards et al. (1981) reported that, based on a sample of pigs with a wide range in backfat thickness, the variables used to estimate muscle content of pork carcasses as described by Fahey et al. (1977) were appropriate. The objectives of the present study were: 1) to reevaluate the equations to predict composition of market hogs of known age or days on test by including a broader spectrum of the population that included both gilts and barrows possessing large variations in type, weight and composition and 2) to develop a method to incorporate age or days on test with compositional data in order to estimate the rate of growth of lean for comparative purposes.

#### Experimental Procedures

The sample of pigs used in this study was composed of an equal number of barrows and gilts representing four distinctly different body types as established by various crossbreeding plans. The types included: maternal × maternal (Landrace × Yorkshire or the reciprocal cross), paternal × paternal (Duroc × Hampshire or the reciprocal cross), paternal × maternal (Duroc or Hampshire × white, crossbred females of Yorkshire or Landrace breeding) and a crossbred group produced by mating boars positive for the porcine stress syndrome, to crossbred females of mixed breed composition.

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Litters were weaned at 42 d, at which time the boars were castrated. At an average age of approximately 10 wk, when ranging in weight from 19 to 42 kg, 192 pigs were allocated to test lots. Three barrows and three gilts of the same body type were assigned randomly to each of 32, 2.4 × 4.9 m pens (concrete floors) located in two modified buildings (open-front) of similar design. Two pens of each type were assigned randomly to each of the four weight end points: 91, 104, 118 or 132 kg. Each pen was started on test when the average pen weight reached 32 kg. Subsequently, the pigs were weighed every 2 wk until they approached their predesignated final weight, at which time, they were weighed weekly. Hogs were removed from test on an individual basis when they attained their weight end point. By mistake, one pen containing paternal × paternal pigs was taken to 132 kg rather than its designated 118 kg.

Two hogs were eliminated from the experiment before completion of the test; one because of an extended period of weight loss diagnosed to have resulted from an esophageal ulcer and the second after development of a rectal prolapse. The pigs were ad libitum fed a pelleted, 16% protein fortified corn-soybean meal diet (table 1) throughout the trial.

After conventional slaughtering (head off, jowl, feet and skin on) at a commercial plant, the following data were collected: hot carcass weight, medial backfat thickness opposite the first, seventh and last ribs and last lumbar vertebra; length from the anterior tip of the aitch bone to the anterior edge of the first rib and next to the vertebra; fat depth and loin muscle depth perpendicular to the skin surface at the one-half and three-fourths distances from the medial side of the longissimus muscle at the sixth and last ribs; longissimus muscle area (LMA) at the sixth, 10th and last rib cross sections; fat depth at the three-fourths distance from the medial side of the longissimus muscle at the 10th rib; depth of the chine bone at the 10th rib, and depth of lumbar lean adjacent to the last lumbar vertebra. Measurements taken with calipers included thickness through the flank of the ham, shoulder thickness and belly pocket thickness (thinnest location) as outlined by Cross et al. (1970). Scores for belly thickness (1 = thin, 6 = thick), muscling (USDA, 1970), seam fat at the sixth rib, color, marbling (NPPC, 1976) and firmness of the longissimus muscle at the sixth, 10th and last ribs also were assessed. Fat depth at the 10th and last ribs and over the ham approximately 10 cm from the dorsal midline was determined with a Hennessy and Chong Fat Depth Indicator (HFDI) probe. All measurements except hot carcass weight were made the day after slaughter.

One side from each carcass was frozen and stored in plastic until all hogs had been slaughtered. Five sides were either lost at the commercial packing plant or incurred an excessive amount of trimming in the slaughtering process to warrant their being eliminated from the study.

The sides were thawed at 4 C for 4 to 5 d. One to 3 hr before cutting, the sides were moved into the 7 C cutting room. Each side was standardized for trim by removing 1) the tail between the first and second coccygeal vertebrae, 2) the diaphragm, 3) the jowl from the atlas vertebra cranially, 4) the sternum, 5) the leaf fat and 6) the cartilage tips of the ribs. The sides were weighed and then separated into wholesale cuts. Each cut was weighed and then the loin, belly and shoulder were each separated into skin, bone and soft tissue. The hams were separated into skin, subcutaneous fat, intermuscular fat, muscle and bone. Once weighed, the fat and muscle from the ham was combined. The soft tissue from each cut was separately ground and mixed and then subjected to an X-ray fat analyzer[6] to determine percentage lipid (Young et al., 1976). The four cuts of each side were proportionately summed to calculate total carcass lipid and lipid-free lean.

Four dependent variables were chosen for analysis. They included kilograms of carcass lean containing 10% fat (FSL), percentage lean in the standardized side, FSL gained/day on test (LDOT) and FSL produced/day of age (LDOA). The first two variables permit comparisons among carcasses when no production information is available. They were included to facilitate the comparison of data generated in this experiment with that obtained from other experiments.

The weight of lipid-free lean was standardized to contain 10% fat by dividing it by .92. This constant was based on the assumption that fat contains about 80% lipid (Fahey et al., 1977). Thus, 100 kg lean containing 10% fat is

[6] Anyl-Ray Model M-201, Anyl-Ray Corp., Sarasota, FL 33580.

TABLE 1. COMPOSITION OF DIET

| Item | % |
|---|---|
| Ground corn (8.9% CP; IFN 4-02-931) | 75.00 |
| Soybean meal (44% CP; IFN 5-04-612) | 16.25 |
| Dehydrated alfalfa meal (17% CP; IFN 1-00-025) | 2.50 |
| Meat and bone meal (50% CP; IFN 5-00-388) | 2.50 |
| Pellet binder | 1.25 |
| Vitamin, trace mineral and antibiotic premix[a] | 1.00 |
| Dicalcium phosphate (22% Ca, 28.5% P; IFN 6-01-080) | .85 |
| Calcium carbonate (39% Ca; IFN 6-01-069) | .40 |
| Salt | .25 |

[a]Contributed the following per kg of diet: 3,300 IU vitamin A, 1,650 IU vitamin $D_3$, 5.5 mg riboflavin, 8.8 mg pantothenic acid, 22 mg niacin, 33 μg vitamin $B_{12}$, 2.2 mg vitamin K, 70 mg Fe, 4 mg Cu, 55 mg Mn, 80 mg Zn, 300 μg I, 120 μg Se and 44 mg Lincomycin.

composed of 90 kg fat-free lean plus 8 kg lipid plus 2 kg water and connective tissue. Therefore, total lipid-free lean divided by .92 equals the weight of FSL. The FSL in the carcass was calculated by doubling the weight of FSL in the one side. Percentage lean in the standardized side was calculated by dividing the weight of FSL by the standardized side weight and multiplying by 100. Percentage lean in the hot carcass before standardizing can be determined by dividing the FSL in the carcass by hot carcass weight and multiplying by 100.

Fat-standardized lean gained/day on test was calculated by subtracting the weight of lipid-free lean in the pig when put on test, from the actual weight of lipid-free lean in the carcass at slaughter, and dividing the difference by days on test and by .92 (to standardize the lipid-free lean to a 10% fat basis). The equation used to predict kg lipid-free lean in the pig when put on test is

$$Y = -1.59 + .44X,$$

where X is live weight (kg) of the feeder pig (Brannaman et al., 1982). This equation is based on data from pigs of the same body types and sexes included in our study. The feeder pigs were slaughtered at the weights that our pigs were started on test. The equation has an $R^2$ of .95, with no sex or type effects. Therefore, it should give a reasonable estimate of the initial lean for the pigs used in this experiment. Because variation in lean content at birth was considered to be small, actual FSL produced/day of age was calculated by dividing the weight of FSL in the carcass by the age of the pig at slaughter.

Both LDOT and LDOA estimate the rate of growth of lean tissue. This is in contrast to total average daily gain, which includes the deposition of adipose tissue. Thus, these two variables provide the means for comparisons among pigs based on their efficiency of growth of lean tissue alone.

The data were analyzed by using simple correlation procedures and stepwise multiple regression equations (Draper and Smith, 1982).

TABLE 2. MEANS, STANDARD DEVIATIONS AND MINIMUM AND MAXIMUM VALUES FOR SELECTED TRAITS OF 185 CARCASSES

| Trait | Mean | SD[a] | Minimum to maximum |
|---|---|---|---|
| Hot carcass weight, kg | 84.6 | 12.3 | 63.1 to 107.1 |
| Carcass length, cm | 84.3 | 3.8 | 76.0 to 94.0 |
| Longissimus muscle area (10th rib), $cm^2$ | 35.4 | 5.6 | 24.2 to 48.7 |
| Fat depth (3/4, 10th rib), cm | 3.0 | .8 | 1.4 to 4.8 |
| Backfat (last rib), cm | 2.5 | .5 | 1.4 to 4.2 |
| Backfat (average), cm[b] | 3.3 | .6 | 2.0 to 4.9 |
| USDA muscling score[c] | 12.2 | 1.9 | 8.0 to 18.0 |

[a]Standard deviation.

[b]Average of measurements taken at first rib, last rib and last lumbar vertebra.

[c]1 = very thin −, 18 = very thick +.

TABLE 3. SIMPLE CORRELATIONS BETWEEN CARCASS TRAITS[a,b]

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Kg lean in carcass (FSL) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2. % lean in standardized side | .09 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. Lean gained/day on test (LDOT) | .26 | .56 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Lean produced/day of age (LDOA) | .52 | .40 | .79 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. Hot carcass weight | .86 | −.39 | −.03 | .28 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. Backfat, 1st rib | .37 | −.59 | −.26 | −.02 | .61 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. Backfat, 7th rib | .29 | −.66 | −.20 | −.03 | .57 | .79 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. Backfat, last rib | .33 | −.65 | −.24 | −.06 | .61 | .71 | .83 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. Backfat, last lumbar | .13 | −.70 | −.28 | −.07 | .45 | .69 | .75 | .78 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. Backfat average[c] | .31 | −.71 | −.29 | −.05 | .62 | .90 | .87 | .90 | .91 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11. Fat depth, 1/2, 6th rib | .16 | −.63 | −.31 | −.16 | .45 | .64 | .67 | .62 | .65 | .70 | | | | | | | | | | | | | | | | | | | | | | | | |
| 12. Fat depth, 3/4, 6th rib | .19 | −.56 | −.27 | −.12 | .44 | .62 | .62 | .62 | .62 | .69 | .80 | | | | | | | | | | | | | | | | | | | | | | | |
| 13. Fat depth, 3/4, 10th rib | .20 | −.80 | −.31 | −.15 | .56 | .76 | .82 | .79 | .78 | .86 | .75 | .70 | | | | | | | | | | | | | | | | | | | | | | |
| 14. Fat depth, 1/2, last rib | .20 | −.68 | −.23 | −.10 | .51 | .68 | .73 | .74 | .76 | .80 | .65 | .63 | .82 | | | | | | | | | | | | | | | | | | | | | |
| 15. Fat depth, 3/4, last rib | .21 | −.69 | −.25 | −.12 | .52 | .70 | .76 | .78 | .77 | .83 | .68 | .68 | .84 | .95 | | | | | | | | | | | | | | | | | | | | |
| 16. LMA[d], 6th rib | .58 | .12 | .14 | .28 | .49 | .10 | .12 | .11 | −.02 | .07 | −.07 | −.05 | −.03 | .00 | .02 | | | | | | | | | | | | | | | | | | | |
| 17. LMA[d], 10th rib | .73 | .25 | .21 | .33 | .56 | .04 | .06 | .12 | −.11 | .01 | −.09 | −.04 | −.15 | −.06 | −.05 | .65 | | | | | | | | | | | | | | | | | | |
| 18. LMA[d], last rib | .68 | .09 | .21 | .35 | .59 | .15 | .15 | .22 | .03 | .14 | .02 | .03 | .04 | .08 | .08 | .56 | .68 | | | | | | | | | | | | | | | | | |
| 19. Carcass length | .69 | −.18 | .07 | .40 | .72 | .34 | .19 | .19 | .16 | .27 | .24 | .20 | .28 | .19 | .17 | .36 | .31 | .43 | | | | | | | | | | | | | | | | |
| 20. Loin depth, 1/2, 6th rib | .34 | .21 | .27 | .25 | .23 | −.12 | −.04 | −.03 | −.14 | −.11 | −.13 | −.06 | −.20 | −.14 | −.10 | .57 | .52 | .40 | .10 | | | | | | | | | | | | | | | |
| 21. Loin depth, 3/4, 6th rib | .41 | .03 | .09 | .19 | .36 | .10 | .14 | .18 | .07 | .13 | .02 | .06 | .02 | .06 | .10 | .54 | .50 | .52 | .16 | .57 | | | | | | | | | | | | | | |
| 22. Loin depth, 1/2, last rib | .50 | −.05 | .03 | .13 | .48 | .18 | .24 | .27 | .14 | .21 | .13 | .10 | .12 | .06 | .12 | .41 | .52 | .63 | .21 | .44 | .43 | | | | | | | | | | | | | |

Table 3 – continued:

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23. Loin depth, 3/4, last rib | .45 | .13 | .06 | .18 | .45 | .23 | .24 | .26 | .15 | .23 | .20 | .18 | .18 | .14 | .17 | .30 | .36 | .50 | .26 | .24 | .38 | .63 | | | | | | | | | | | | |
| 24. Seam fat score, 6th rib[ef] | .23 | −.47 | −.04 | −.04 | .45 | .41 | .45 | .46 | .43 | .48 | .46 | .42 | .63 | :50 | .50 | −.02 | .00 | .12 | .23 | −.04 | .04 | .14 | .22 | | | | | | | | | | | |
| 25. Belly score[g] | .08 | −.46 | −.23 | −.04 | .29 | .34 | .38 | .43 | .48 | .45 | .38 | .38 | .44 | .42 | .46 | −.09 | −.09 | .06 | .16 | −.10 | −.01 | .11 | .14 | .21 | | | | | | | | | | |
| 26. Belly pocket thickness | .12 | −.49 | −.21 | .00 | .34 | .41 | .46 | .48 | .53 | .52 | .43 | .43 | .52 | .49 | .51 | .01 | −.12 | .01 | .21 | −.12 | .04 | .01 | .08 | .34 | .73 | | | | | | | | | |
| 27. Lumbar lean depth, last lumber | .38 | .22 | .29 | .47 | .24 | −.04 | −.02 | .01 | −.06 | −.03 | −.12 | −.12 | −.13 | −.02 | −.07 | .35 | .39 | .32 | .28 | .20 | .19 | .06 | .08 | −.17 | −.02 | .01 | | | | | | | | |
| 28. Ham width | .73 | −.09 | .10 | .35 | .72 | .47 | .41 | .41 | .26 | .42 | .27 | .28 | .28 | .31 | .29 | .42 | .55 | .44 | .50 | .21 | .29 | .38 | .35 | .19 | .11 | .22 | .33 | | | | | | | |
| 29. Shoulder width | .49 | −.31 | −.05 | .03 | .60 | .41 | .44 | .43 | .34 | .43 | .35 | .33 | .38 | .32 | .37 | .36 | .40 | .32 | .22 | .20 | .28 | .34 | .33 | .39 | .15 | .22 | .00 | .47 | | | | | | |
| 30. USDA muscling score[h] | .50 | .30 | .27 | .32 | .32 | −.03 | −.02 | .03 | −.16 | −.06 | −.13 | −.12 | −.21 | −.14 | −.18 | .35 | .60 | .37 | .19 | .28 | .23 | .28 | .22 | −.12 | −.24 | −.25 | .26 | .49 | .29 | | | | | |
| 31. Marbling score | −.22 | −.04 | −.02 | −.15 | −.19 | −.16 | −.12 | −.12 | −.19 | −.18 | −.07 | −.08 | −.06 | −.15 | −.13 | −.08 | −.14 | −.12 | −.08 | −.09 | −.13 | −.15 | −.07 | .02 | −.14 | −.19 | −.14 | −.32 | −.03 | −.08 | | | | |
| 32. Chine bone depth | .40 | .11 | .15 | .24 | .31 | −.01 | .05 | .05 | −.04 | −.01 | −.07 | −.07 | −.02 | .07 | .03 | .42 | .55 | .42 | .21 | .26 | .29 | .24 | .20 | .03 | −.05 | −.07 | .33 | .30 | .20 | −.13 | .28 | | | |
| 33. Probe ham[ij] | .00 | −.43 | −.20 | −.08 | .21 | .36 | .41 | .44 | .35 | .42 | .34 | .36 | .42 | .41 | .38 | −.08 | −.17 | −.06 | .05 | −.04 | .03 | −.05 | .11 | .31 | .20 | .24 | .00 | .09 | .14 | −.07 | −.02 | −.04 | | |
| 34. Probe, last rib[ij] | .11 | −.67 | −.23 | −.07 | .45 | .65 | .73 | .72 | .69 | .76 | .62 | .58 | .80 | .72 | .73 | −.07 | −.20 | −.04 | .20 | −.17 | .01 | .03 | .13 | .46 | .35 | .38 | −.06 | .20 | .26 | −.14 | −.16 | −.09 | .59 | |
| 35. Probe, 10th rib[ij] | .10 | −.65 | −.24 | −.11 | .41 | .60 | .71 | .71 | .64 | .71 | .58 | .54 | .75 | .69 | .68 | −.05 | −.17 | −.06 | .15 | −.12 | .00 | .02 | .17 | .51 | .30 | .18 | −.01 | .19 | .25 | −.07 | −.21 | −.03 | .54 | .75 |

[a]N=185 except as otherwise noted.

[b]P<.05 is r≥±.15; P<.01 if r≥±.19.

[c]Average of first rib, last rib and last lumbar vertebra.

[d]Longissimus muscle area.

[e]N=184.

[f]1 = slight, 5 = very abundant.

[g]1 = thin, 6 = thick.

[h]1 = very thin −, 18 = very thick +.

[i]Hennessy and Chong Fat Depth Indicator.

[j]N=173.

Sex and type interactions were studied in the regression equations that are currently applicable to swine improvement or carcass contest situations.

Data from a group of 38 boar carcasses from a commercial operation were used to evaluate the regression equations predicting kilograms and percentage lean. These carcasses were obtained independently from the original group but were treated in a similar manner except that the head was left on. Production information was not available so we were unable to evaluate the equations predicting LDOT or LDOA.

## Results and Discussion

Summary statistics that characterize the sample are presented in table 2. Because of selection procedures and numbers, there was greater variability, especially in fatness, within this group of hogs as compared with those used in the Fahey et al. (1977) study. The variation was similar to that in the Edwards et al. (1981) experiment.

Simple correlation coefficients between carcass traits are given in table 3. There was a positive correlation between the weight of FSL and all carcass traits except marbling and HFDI probe measured at the ham. In contrast, Fahey et al. (1977) reported a negative correlation between the weight of corrected fat-free lean in the carcass and backfat thickness. In addition, Edwards et al. (1981) found a negative correlation between the weight of muscle in the four lean cuts and backfat thickness. The difference in results may be partly accounted for by the larger range in carcass weights in the present study. As anticipated, measures of weight, muscling and skeletal size were more highly correlated with FSL than were estimates of fatness. The correlations between FSL and hot carcass weight, muscling score and length were .86, .50 and .69, respectively, while the correlations between FSL and fatness measurements ranged from .10 to .37. The correlation of LMA at the 10th rib with FSL was .73, similar to that presented by Fahey et al. (1977).

Percentage lean in the side had high, negative correlations with measures of fatness but lower, positive correlations with muscling characteristics. Several investigators (Cross et al., 1970; Smith and Carpenter, 1973; Fahey et al., 1977; Edwards et al., 1981) have previously reported correlations of .48 to .71 between percentage lean and longissimus muscle area or muscling score, whereas in this experiment, the correlations ranged from .09 to .30, depending on the location where LMA was measured. This difference in results suggest that although there was considerable variation in muscling in this sample (table 2), the variation in fatness had an overriding influence on percentage lean. This influence was not as obvious in previous studies.

Low, negative correlations were noted between LDOT and fatness measurements. Low, positive correlations were found between LDOT and most muscling characteristics.

Lean produced/day of age had low, negative correlations with most measures of fatness and, generally, low, positive correlations with most muscling and skeletal size characteristics.

Multiple regression equations to predict kilograms of fat-standardized carcass lean are presented in table 4. Equation 1 includes variables measured on the intact carcass and that are used in the current USDA pork carcass grading system. Hot carcass weight and average backfat thickness accounted for 83% of the variation in the weight of carcass lean. The addition of USDA muscling score increased the $R^2$ to 85%. When carcass length was included in this equation, it failed to produce a significant effect. Over a range of 3.30 to 5.33 cm in average backfat thickness, Edwards et al. (1981) found that carcass weight and average backfat thickness accounted for 77% of the variation in the weight of lean in the four lean cuts. Similarly, Fahey et al. (1977) reported an $R^2$ of 64% for the prediction of weight of corrected fat-free lean in the carcass when carcass weight and average backfat were included as independent variables.

Measurement of backfat thickness at only one location rather than three would be quicker and more easily standardized for rapid, on-line use in large volume abattoirs. The combination of last rib backfat thickness with muscling score and carcass weight in this study (equation 2), resulted in an $R^2$ less than 1% lower than that obtained in equation 1, which included an average of three fat measurements. Last rib backfat is easy to measure and seems to be less affected by poor splits (avoiding inaccurate measurements) than backfat measurements taken at the first rib or last lumbar vertebra. A similar finding was noted by Kempster and Evans (1979).

The determination of subjective characteristics cannot be as easily standardized and are more susceptible to bias and human error than are objective measures. For evaluating muscling

TABLE 4. EQUATIONS TO PREDICT KILOGRAMS OF FAT-STANDARDIZED LEAN

| Equation | Independent variables | Intercept | b value | Significance level | No. | $R^2 \times 100$, % | SD[a] |
|---|---|---|---|---|---|---|---|
| 1 | Hot carcass weight, kg | 5.34 | .511 | <.001 | 185 | 84.80 | 2.48 |
| | Backfat, average, cm | | −3.16 | <.001 | | | |
| | USDA muscling score[b] | | .520 | <.001 | | | |
| 2 | Hot carcass weight, kg | 2.63 | .493 | <.001 | 185 | 84.17 | 2.53 |
| | Backfat, last rib, cm | | −3.08 | <.001 | | | |
| | USDA muscling score[b] | | .648 | <.001 | | | |
| 3 | Hot carcass weight, kg | 5.64 | .487 | <.001 | 185 | 84.69 | 2.50 |
| | Backfat, last rib, cm | | −2.51 | <.001 | | | |
| | Muscling groups[c] | | 1.63 | <.001 | | | |
| | Sex[d] | | 1.66 | <.001 | | | |
| 4 | Hot carcass weight, kg | 4.76 | .505 | <.001 | 185 | 87.65 | 2.24 |
| | Fat depth, 3/4, 10th rib, cm | | −2.66 | <.001 | | | |
| | Longissimus muscle area, 10th rib, $cm^2$ | | .141 | <.001 | | | |
| 5 | Hot carcass weight, kg | 7.05 | .488 | <.001 | 183 | 82.38 | 2.68 |
| | Fat depth, 1/2, 6th rib, cm | | −2.17 | <.001 | | | |
| | Longissimus muscle area, 6th rib, $cm^2$ | | .141 | .012 | | | |
| | Seam fat score[e] | | −.699 | .019 | | | |
| 6 | Hot carcass weight, kg | 4.38 | .466 | <.001 | 184 | 84.30 | 2.52 |
| | Fat depth, 3/4, last rib, cm | | −2.08 | <.001 | | | |
| | Longissimus muscle area, last rib, $cm^2$ | | .217 | <.001 | | | |
| 7 | Hot carcass weight, kg | 3.82 | .483 | <.001 | 173 | 84.09 | 2.47 |
| | Fat depth, last rib, probe[f], mm | | −.239 | <.001 | | | |
| | USDA muscling score[b] | | .615 | <.001 | | | |

[a]Standard deviation.

[b]1 = very thin −, 18 = very thick +.

[c]1 = thin, 2 = intermediate, 3 = thick.

[d]1 = gilt, 0 = barrow.

[e]1 = slight, 5 = very abundant.

[f]Hennessy and Chong Fat Depth Indicator.

scores then, there must be distinct differences between shapes to reduce the variability in scoring by different evaluators. A three-score system for muscling (thick, intermediate or thin) would seem to be easier and quicker to use than the current USDA six categories that often are further subdivided into thirds, as was done in this study. If our sample is representative of the total market hog population, it is likely that the majority of carcasses will fall into the intermediate category. Only carcasses with significant deviations from the average would be classified as thick or thin. The division of the carcasses in this study into these three muscling groups, combined with hot carcass weight and last rib backfat thickness, explained 83% of the variation in carcass lean. This was about a 1% decrease from the $R^2$ determined for the same traits when muscling was classified with the 18-score system. There was a significant interaction with sex in this equation and therefore, it was included (equation 3). This increased the $R^2$ to about 85%. An analysis of the partial regression coefficients for this equation indicated that a change of one muscling group (three scale basis) is equivalent to an opposite change in last rib backfat of .66 cm.

The best equation for predicting kilograms of FSL with three independent variables, included hot carcass weight, fat depth at the three-fourths position at the 10th rib and ham width ($R^2$ = .88%). Little difference in predictive accuracy, however, was found between this equation and one including LMA at the 10th rib rather than ham width (equation 4). Fahey et al. (1977) and Edwards et al. (1981) also found that weight, fat depth and LMA were good predictors of the weight of lean in the carcass or the four lean cuts. In the Fahey et al. (1977) study, though, the partial regression coefficient for LMA was more than twice as large, and that for fat slightly smaller than in the present study. This seems to be a reflection of the variation in traits in each of the samples used to establish the equations. It emphasizes, however, the small effect that differences in muscling had in this sample, as compared with fatness. A change in LMA of 1 $cm^2$ is equivalent to an opposite change in fat depth of only .05 cm.

Measurements taken at the sixth rib had little advantage over those measured on the intact carcass, except that breaking the carcass would permit an evaluation of muscle quality (color, marbling and firmness) and quantity of intermuscular fat. As shown in equation 5, these measurements accounted for 82% of the variation in carcass lean weight. A similar result was reported by Fahey et al. (1977).

A measurement of fat depth, 6.5 cm from the dorsal midline at the last rib ($P_2$) currently is used in the British Meat and Livestock Commission classification scheme (Kempster and Evans, 1979). In a comparison of different fat measurement locations, Kempster and Evans (1979) found that the $P_2$ fat depth gave the lowest residual standard deviation for the prediction of percentage lean in the carcass. In our study, the combination of hot carcass weight and fat depth at the three-fourths position over the longissimus muscle of the last rib accounted for 83% of the variation in the weight of lean in the carcass. The $R^2$ was increased to 84% when LMA at the last rib was included in the equation (equation 6). As evidenced by these results, there does not seem to be any advantage to ribbing the carcass at the last rib rather than at the 10th rib. However, probe measurements of fatness at the last rib on the intact carcass seem to have some predictive as well as practical value.

The combination of HFDI probe measurement at the last rib and hot carcass weight explained 81% of the variation in carcass lean. The inclusion of USDA muscling score increased the $R^2$ to 84% (equation 7). This was similar to the accuracy obtained when backfat thickness at the last rib midline, measured with a ruler, was used with weight and muscling score. Similarly, Kempster et al. (1981) found no significant difference between last rib fat thickness measured with the HFDI probe and that measured on the cut surface with a ruler.

Equations 3 and 4 were manipulated to facilitate comparisons among carcasses for predicted weight of FSL, in relation to a constant carcass weight of 72.6 kg. Changes were made to the intercept and b value for hot carcass weight in each equation, as indicated by a regression equation predicting FSL from hot carcass weight minus 72.6 kg. The equations are:

$$Y = 37.6 + .047X_1 - 2.51X_2 + 1.63X_3 + 1.66X_4,$$

$$Y = 37.0 + .06X_1 - 2.66X_5 + .141X_6,$$

where

$Y$ = FSL (kg) adjusted to a 72.6 kg carcass weight basis,
$X_1$ = hot carcass weight (kg),
$X_2$ = backfat (last rib, cm),
$X_3$ = muscling groups (1 = thin, 2 = intermediate, 3 = thick),
$X_4$ = sex (1 = gilt, 0 = barrow),
$X_5$ = fat depth (3/4, 10th rib, cm),
$X_6$ = longissimus muscle area (10th rib, $cm^2$).

Because these two equations were developed from other equations, no statistical data were calculated.

Percentage lean in the standardized side may be predicted with similar degrees of accuracy by using fat depth at the three-fourths position of the 10th rib and either LMA at the 10th rib (equation 8, table 5) or USDA muscling score ($R^2$ = 66%). As already mentioned, muscling scores are subjective and are more prone to error than the objective measuring of LMA. Fahey et al. (1977) reported that LMA and fat depth at the 10th rib accounted for 68% of the variation in percentage lean in the carcass. Edwards et al. (1980) found that these variables

TABLE 5. EQUATIONS TO PREDICT PERCENTAGE FAT-STANDARDIZED LEAN IN THE STANDARDIZED SIDE

| Equation | Independent variables | Intercept | b value | Significance level | No. | $R^2$ × 100, % | SD[a] |
|---|---|---|---|---|---|---|---|
| 8 | Fat depth, 3/4, 10th rib, cm | 66.62 | −4.01 | <.001 | 185 | 65.88 | 2.43 |
| | Longissimus muscle area, 10th rib, $cm^2$ | | .102 | .002 | | | |
| 9 | Backfat, last rib, cm | 65.57 | −4.58 | <.001 | 185 | 53.45 | 2.85 |
| | Muscling groups[b] | | 1.73 | <.001 | | | |
| | Sex[c] | | 1.69 | <.001 | | | |

[a]Standard deviation.

[b]1 = thin, 2 = intermediate, 3 = thick.

[c]1 = gilt, 0 = barrow.

accounted for about 87% of the variation in percentage lean in the four lean cuts.

When the carcass is unribbed, percentage lean in the standardized side may be predicted by including last rib backfat and muscling groups as independent variables (equation 9). A considerably lower $R^2$ results though, when last rib backfat is included rather than 10th rib fat depth. Sex was a significant variable in this equation and it was thus included.

Equations to predict kilograms of lean gained/day on test are presented in table 6. These equations are useful in determining the lean growth of pigs from the feeder pig stage to slaughter as market hogs. They account for differences in on-test weight and days on test and therefore may be used to compare pigs that are put on test at different weights and for different periods of time. The equation with the greatest predictive accuracy (equation 10) incorporates the variables that best predicted the weight of lean in the carcass (hot carcass weight and fat depth and LMA at the 10th rib), on-test weight and days on test. This equation is recommended for use in the evaluation of carcasses that are split at the 10th rib. When

TABLE 6. EQUATIONS FOR PREDICTING KILOGRAMS OF FAT-STANDARDIZED LEAN GAINED PER DAY ON TEST

| Equation | Independent variables | Intercept | b value | Significance level | No. | $R^2$ × 100, % | SD[a] |
|---|---|---|---|---|---|---|---|
| 10 | On-test weight, kg | .412 | −.00438 | <.001 | 185 | 60.59 | .025 |
| | Time on test, d | | −.00316 | <.001 | | | |
| | Hot carcass weight, kg | | .00471 | <.001 | | | |
| | Fat depth, 3/4, 10th rib, cm | | −.0277 | <.001 | | | |
| | Longissimus muscle area, 10th rib, $cm^2$ | | .00127 | .023 | | | |
| 11 | On-test weight, kg | .420 | −.00428 | <.001 | 185 | 52.66 | .028 |
| | Days on test | | −.00298 | <.001 | | | |
| | Hot carcass weight, kg | | .00424 | <.001 | | | |
| | Backfat last rib, cm | | −.0269 | <.001 | | | |
| | Muscling groups[b] | | .0187 | <.001 | | | |
| | Sex[c] | | .0112 | <.001 | | | |

[a]Standard deviation.

[b]1 = thin, 2 = intermediate, 3 = thick.

[c]1 = gilt, 0 = barrow.

TABLE 7. EQUATIONS FOR PREDICTING KILOGRAMS OF FAT-STANDARDIZED LEAN PRODUCED PER DAY OF AGE

| Equation | Independent variables | Intercept | b value | Significance level | No. | $R^2 \times$ 100, % | SD[a] |
|---|---|---|---|---|---|---|---|
| 12 | Age, d | .288 | −.00145 | <.001 | 185 | 71.21 | .013 |
| | Hot carcass weight, kg | | .00291 | <.001 | | | |
| | Fat depth, 3/4, 10th rib, cm | | −.0162 | <.001 | | | |
| | Longissimus muscle area, 10th rib, $cm^2$ | | .000657 | .030 | | | |
| 13 | Age, d | .289 | −.00140 | <.001 | 185 | 64.86 | .015 |
| | Hot carcass weight, kg | | .00267 | <.001 | | | |
| | Backfat, last rib, cm | | −.0151 | <.001 | | | |
| | Muscling groups[b] | | .0102 | <.001 | | | |
| | Sex[c] | | .00786 | .003 | | | |

[a]Standard deviation.

[b]1 = thin, 2 = intermediate, 3 = thick.

[c]1 = gilt, 0 = barrow.

splitting is not feasible, an equation that includes last rib backfat may be used (equation 11). As in the previous equations that included last rib backfat rather than 10th rib fat depth, there was a significant interaction with sex.

When the age of the hog can be verified, kilograms of lean produced/day of age may be estimated (table 7). Again, the equation using 10th rib measurements explains the greatest variability in lean per day of age. Sex was a significant variable when included in the unribbed carcass equation.

The interactions of sex and type in the equations that are applicable to carcass contests or swine evaluation programs are summarized in table 8. Overall, there was a significant effect of sex in the equations that included last rib backfat in contrast to those that included 10th rib fat depth. It is evident that 10th rib fat depth accounted for enough of the variability in compositional differences such that sex was not a factor.

In general, it was found that body type had a significant effect when included in each regression equation. Nevertheless, there does not seem to be any practical way to adjust for this interaction because of the wide variation (and sometimes unknown breeding history) of pigs found in multibreed contests.

Data from the 38 independent carcasses were used to evaluate equations 4 and 8. There was less variability within this group of carcasses than that of the original 185 carcasses. The means and standard deviations of the carcass traits used as independent variables are: hot, carcass weight (head-on), 77.9 ± 9.0 kg; LMA at the 10th rib, 31.9 ± 4.4 $cm^2$ and fat depth at the 10th rib, 1.8 ± .4 cm.

The correlation of actual kg lean in the carcass and that predicted by equation 4 was .85 ($r^2$ = .72; P<.001). The correlation of actual percentage lean in the standardized side and that predicted by equation 8 was .34 ($r^2$ = .12; P<.05). These results indicate that the weight

TABLE 8. SEX AND BODY TYPE EFFECTS IN SELECTED PREDICTION EQUATIONS

| Equation[a] | Sex | Body type | Sex X type |
|---|---|---|---|
| 3 | *** | *** | NS[b] |
| 4 | NS | ** | NS |
| 8 | NS | * | NS |
| 9 | *** | *** | NS |
| 10 | NS | ** | NS |
| 11 | *** | *** | NS |
| 12 | NS | *** | NS |
| 13 | ** | *** | NS |

[a]Refer to tables 4, 5, 6 and 7 for variables.

[b]NS = nonsignificant (P>.10).

*P<.10.

**P<.01.

***P<.001.

of lean in the carcass can be predicted with a high degree of accuracy. Percentage lean, however, cannot be predicted as well and it is recommended that this method not be used. This was also reflected in the $R^2$ values that were obtained in the original analysis of these equations.

It is evident from the results of this experiment that carcass composition can best be predicted from measurements of fat depth and LMA at the 10th rib. By incorporating production information with carcass data, the rate of carcass lean growth can be predicted. This information should enable the producer to be more accurate in selecting breeding lines that will produce lean pork in the most efficient time.

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