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Abstract

Equations for predicting the quantity of lean in the young pig were developed from measurements on 48 pigs (16.8 to 48.5 kg body weight) representing four crossbred mating types; maternal breed(s) × maternal breed(s), paternal breed(s) × maternal breed(s), paternal breed(s) × paternal breed(s) and porcine stress-susceptible × mixed breed. Within litter and sex, each of three pigs was assigned randomly to a light, intermediate or heavy slaughter weight group such that each mating type was represented by six barrows and six gilts from four different litters. Thirteen measurements were obtained for each pig; body weight, body length, body circumference, front leg circumference, front leg length, shoulder depth, shoulder width, ham width, head width, shoulder fat, last rib fat, last lumbar fat and loin muscle depth. Fat measurements and loin depth were taken ultrasonically. Pigs were slaughtered, chilled and manually separated into lean and fat, bone, skin and feet and tail components. Fat composition was determined by the Goldfisch method and also an x-ray absorption procedure. Pigs averaged 32.0 kg body weight and 12.5 kg of lean. Prediction equations were developed by maximum R^2 and stepwise regression procedures. The model that includes the 13 measured variables and average backfat produced a .97 R^2 when predicting kilograms of lean (LWTA). Body weight was the only significant variable. The one-variable model of body weight ($P<.01$) produced a .95 R^2 Kilograms of lean was estimated for an additional 24 pigs using the one-variable model of body weight and the two-variable model of body weight and shoulder width. The variable LWTA was found to be highly correlated with both estimates of LWTA ($r = .97$). Results suggest that LWTA can be predicted using a simple model that could be adapted to applied situations.

Keywords

Prediction Equations, Swine, Lean, Body Weight

Disciplines

Agriculture | Animal Sciences

Comments

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PREDICTION EQUATIONS FOR ESTIMATING LEAN QUANTITY IN 15- TO 50-KG PIGS[1]

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Summary

Equations for predicting the quantity of lean in the young pig were developed from measurements on 48 pigs (16.8 to 48.5 kg body weight) representing four crossbred mating types; maternal breed(s) × maternal breed(s), paternal breed(s) × maternal breed(s), paternal breed(s) × paternal breed(s) and porcine stress-susceptible × mixed breed. Within litter and sex, each of three pigs was assigned randomly to a light, intermediate or heavy slaughter weight group such that each mating type was represented by six barrows and six gilts from four different litters. Thirteen measurements were obtained for each pig; body weight, body length, body circumference, front leg circumference, front leg length, shoulder depth, shoulder width, ham width, head width, shoulder fat, last rib fat, last lumbar fat and loin muscle depth. Fat measurements and loin depth were taken ultrasonically. Pigs were slaughtered, chilled and manually separated into lean and fat, bone, skin and feet and tail components. Fat composition was determined by the Goldfisch method and also an x-ray absorption procedure. Pigs averaged 32.0 kg body weight and 12.5 kg of lean. Prediction equations were developed by maximum R^2 and stepwise regression procedures. The model that includes the 13 measured variables and average backfat produced a .97 R^2 when predicting kilograms of lean (LWTA). Body weight was the only significant variable. The one-variable model of body weight ($P<.01$) produced a .95 R^2 Kilograms of lean was estimated for an additional 24 pigs using the one-variable model of body weight and the two-variable model of body weight and shoulder width. The variable LWTA was found to be highly correlated with both estimates of LWTA (r = .97). Results suggest that LWTA can be predicted using a simple model that could be adapted to applied situations.

(Key Words: Prediction Equations, Swine, Lean, Body Weight.)

Introduction

Changes in body weight over time have been used as the basis for determining growth rate and efficiency in swine. Exclusive use of these measures disregards body composition and often may result in selecting animals that are fast growing but undesirable in carcass composition. Identifying market pigs that excel in both production efficiency and carcass desirability should result ultimately in production programs that increase kilograms of edible pork/kilogram of feed consumed and provide a palatable and lean product. Procedures to identify market pigs that excel in both production and carcass desirability require determining lean gain on test. Evaluation of lean gain during a performance test of swine varying in weight and age requires estimation of initial and final composition. Procedures for estimating lean quantity in market pigs are available (NPPC, 1976; Fahey et al., 1977), but procedures for estimating lean quantity in young pigs are not well established. One procedure for estimating muscle quantity in 25- to 45-kg pigs is available (Prince et al., 1981), but its reliability has not been confirmed. More research to develop a practical and accurate method of estimating lean quantity in young pigs is needed. This would allow for determining lean gain and efficiency during a test period regardless of body type and carcass composition. The objectives of this study were (1) to determine the quantity of lean in 15- to 50-kg pigs, (2) to

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identify live pig measurements that would indicate lean quantity, (3) to develop prediction equations for estimating lean quantity in young pigs based on live pig measurements, (4) to evaluate previous results with the conclusions of Prince et al. (1981) and with those found in this study and (5) to validate results found in this study by using an additional group of 24 pigs.

Experimental Procedure

Forty-eight pigs, selected from a group of 240 pigs, were used. The selected pigs ranged from 16.8 to 48.5 kg in body weight and averaged 32.0 kg. The additional 192 pigs were used in a postweaning study by Grisdale et al. (1982). The 48 pigs were of four crossbred mating types, each representing a contrasting body type: 1) maternal breed(s) × maternal breed(s), which produced animals that were generally long-bodied, narrow in width and somewhat lacking in general musculature; 2) paternal breed(s) × maternal breed(s), whose offspring were intermediate in body length and degree of muscling; 3) paternal breed(s) × paternal breed(s), which resulted in offspring that were shorter-bodied, wider, deeper and more muscular than types one and two and 4) porcine stress-susceptible × mixed breed matings, which yielded animals that were very muscular and produced carcasses with large loin muscle areas. Breeds used as maternal breeds were Landrace and Yorkshire, while Duroc and Hampshire were used as paternal breeds. Within litter and sex, each of three pigs was assigned randomly to a light, intermediate or heavy slaughter weight group such that each mating type was represented by six barrows and six gilts from four different litters. Body weight averages for slaughter weight groups were 24.4, 31.9 and 39.7 kg for light, intermediate and heavy groups, respectively. Thirteen measurements were obtained for each live pig: (1) body weight (BW, kg), (2) body length (BL, cm) measured from parietal bone to fifth coccygeal vertebra, (3) body circumference (BC, cm) measured posterior to forelimb, (4) front leg circumference (LC, cm) measured at midpoint of metacarpus, (5) front leg length (LL, cm) measured from distal tip of radius to distal tip of phalanges, (6) shoulder depth (SD, cm) measured posterior to forelimb, (7) shoulder width (SW, cm) measured at broadest width lateral to scapula, (8) ham width (HW, cm) measured at broadest width lateral to femur, (9) head width (EW, cm) measured between medial edges of eye, (10) shoulder fat (SF, cm) measured ultrasonically[4] 2.5 cm from midline dorsal to first thoracic vertebra, (11) last rib fat (RF, cm) measured ultrasonically[4] 2.5 cm from midline dorsal to last thoracic vertebra, (12) last lumbar fat (LF, cm) measured ultrasonically[4] 2.5 cm from midline dorsal to last lumbar vertebra and (13) loin muscle depth (LD, cm) measured ultrasonically[4] 2.5 cm from midline dorsal to last thoracic vertebra. Measurements were taken 1 d before slaughter.

Pigs were weaned at 42 d and subsequently allowed ad libitum access to a 16% protein, corn-soybean meal diet. Pigs were slaughtered at weekly intervals when they attained a weight within ± 2.3 kg of their predetermined termination weight of either 22.7, 31.8 or 40.8 kg for light, intermediate and heavy slaughter weight groups, respectively. Conventional slaughter procedures (head off, jowl on, feet on, skin on) were followed. The carcasses were chilled for 24 h. After chilling, the right side of each carcass was divided into four major cuts; shoulder, loin, belly and ham. Each cut was separated manually into lean and fat, bone, skin and feet and tail components. Lean and fat components (soft tissue) were ground through a plate with 9.5-mm openings and mixed. A 5.90-kg sample of soft tissue mix was submitted to an x-ray fat analyzer[5] for sample fat percentage determination. The sample analyzed by x-ray absorption for fat was then ground through a plate with 3.2-mm openings, mixed and reground through the same plate. A random sample of approximately 10 g was collected, frozen in liquid N_2 and pulverized in a blender. Sample fat percentage of the pulverized sample was determined by the Goldfisch method (AOAC, 1975). Kilograms of lean determined by using x-ray fat percentage (LWTA) and kilograms of lean determined by using Goldfisch fat percentage (LWTG) were calculated for each carcass. Kilograms of lean were determined by subtracting kilograms of carcass fat from kilograms of carcass soft tissue. Carcass fat was determined by multiplying carcass soft tissue weight by x-ray fat percent-

[4] ILIS Model 717B Series TPM+, International Livestock Improvement Services Corp., Ames, IA.

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

age, if calculating LWTA, and by Goldfisch fat percentage, if calculating LWTG. Total carcass soft tissue was determined by dividing carcass right-side soft tissue weight by carcass right-side weight and then multiplying by total carcass weight.

The data were analyzed by maximum R^2 and stepwise regression procedures (SAS, 1979). The maximum R^2 technique selected the 1- to 14-variable models that maximized the coefficient of determination (R^2). The dependent variables were LWTA and LWTG. The independent variables included the 13 live measurements and average backfat (BF). Prediction equations then were developed from the analysis. In addition, previously suggested formulas (NPPC, 1976; Prince et al., 1981) were also evaluated. An additional 24 pigs (16.3 to 54.9 kg body weight) representing two crossbred mating types, maternal breed(s) × maternal breed(s) and paternal breed(s) × maternal breed(s), were used to validate the results found in this study. The additional pigs were subjected to the same experimental procedure as the original 48 pigs.

Results and Discussion

The means, standard deviations and ranges of variables studied are shown in table 1. Body weight averaged 32.0 kg and ranged from 16.8 to 48.5 kg. Average backfat ranged from .53 to 1.53 cm and averaged .95 cm for the 48 observations. Lean weight average determined by using the Goldfisch fat analysis was higher than the lean weight average determined by using the x-ray fat analysis.

Coefficients of correlation among all variables are in table 2. Body weight had the highest relationship with LWTA and LWTG, and loin muscle depth had the lowest correlation. Body measurements that indicate body capacity, such as body length, body circumference, shoulder depth and shoulder width, also had high relationship with LWTA and LWTG.

Prediction equations were developed with LWTA as the dependent variable. The variable LWTA was chosen rather than LWTG because the x-ray method of fat analysis uses a larger sample than the Goldfisch method. Use of a larger sample should conceivably reduce sampling errors.

Sex and mating type were included in the original models. Sex was not a significant source of variation and was excluded from the final models. Mating type was excluded from the final models because it is essential that lean quantity be predicted across mating types, and mating type failed to be a significant source of variation when included in the final models.

Although the average body weight of pigs in the present study was only .6 kg less than those in the study by Prince et al. (1981), average

TABLE 1. VARIABLE MEASUREMENTS FOR PIGS IN EXPERIMENTAL POPULATION[a]

Variable	Mean	SD	Range Minimum	to	Maximum
Body weight, kg	32.0	7.29	16.8	to	48.5
Body length, cm	79.4	7.34	60.0	to	93.0
Body circumference, cm	67.7	5.82	54.5	to	79.0
Front leg circumference, cm	12.0	.79	10.0	to	13.4
Front leg length, cm	12.0	.87	10.0	to	13.6
Shoulder depth, cm	25.1	2.01	19.8	to	28.9
Shoulder width, cm	20.5	2.00	16.1	to	24.6
Ham width, cm	23.9	1.75	20.7	to	27.9
Head width, cm	6.9	.62	5.3	to	8.0
Shoulder fat, cm	1.44	.32	.90	to	2.10
Last rib fat, cm	.70	.21	.30	to	1.20
Last lumbar fat, cm	.73	.25	.40	to	1.40
Loin muscle depth, cm	2.21	.37	1.50	to	3.00
Average backfat, cm	.95	.25	.53	to	1.53
Lean weight (x-ray), kg	12.5	3.29	6.7	to	19.9
Lean weight (Goldfisch), kg	12.9	3.77	6.8	to	21.1

[a]No. = 48.

TABLE 2. COEFFICIENTS OF CORRELATION BETWEEN VARIABLES[a,b]

Variable	Variable number[c]														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1) Body weight															
2) Body length	.91														
3) Body circumference	.96	.91													
4) Front leg circumference	.70	.61	.76												
5) Front leg length	.81	.81	.81	.67											
6) Shoulder depth	.94	.88	.92	.65	.76										
7) Shoulder width	.92	.79	.90	.75	.76	.87									
8) Ham width	.77	.67	.79	.63	.57	.72	.77								
9) Head width	.88	.84	.85	.72	.71	.85	.83	.65							
10) Shoulder fat	.84	.75	.82	.51	.67	.85	.84	.72	.69						
11) Last rib fat	.81	.71	.78	.47	.66	.82	.81	.64	.64	.94					
12) Last lumbar fat	.74	.63	.71	.46	.65	.73	.77	.54	.62	.84	.89				
13) Loin muscle depth	.63	.57	.66	.65	.57	.54	.65	.50	.63	.45	.41	.56			
14) Average backfat	.83	.73	.80	.50	.68	.83	.84	.66	.68	.97	.98	.94	.48		
15) Lean weight (x-ray)	.98	.87	.94	.69	.77	.93	.93	.76	.86	.84	.79	.75	.65	.83	
16) Lean weight (Goldfisch)	.97	.88	.93	.63	.74	.92	.90	.74	.86	.83	.79	.73	.59	.82	.99

[a]No. = 48.

[b]All values different ($P<.01$) from zero.

[c]Numbers correlate to variable in first column.

LWTA for this study was .7 kg more. The formula recommended by Prince et al. (1981) is kilograms of muscle (KGM) = −13.15 + .24 (BW) − 4.10 (BF) + 2.29 (LD) + .20 (BL). Using this equation the average predicted LWTA of pigs in this study was 11.6 kg. The Prince equation underestimated LWTA by an average 7.6% with a range of 32.4% less to 1.7% more than the actual LWTA for the individual pigs. The NPPC (1976) recommends a value of 6.82-kg of muscle (containing 10% fat) for an 18.2-kg pig, with adjustments of .5 kg muscle/ kg change in body weight. When LWTA was adjusted to a 10% fat basis and compared with

TABLE 3. PREDICTION EQUATIONS FOR ESTIMATING KILOGRAMS OF LEAN IN GROWING PIGS[a]

No. variables	Variable[b]	a value	b value	SE	R^2	SEE[c]	Level of significance
1	BW	−1.59	.44	.01	.95	.715	<.01
2	BW	−5.19	.37	.03	.96	.684	<.01
	SW		.29	.13			.03
3	BW	−5.27	.36	.04	.96	.686	<.01
	SW		.27	.13			.05
	LD		.31	.36			.39
4	BW	−7.81	.32	.05	.96	.686	<.01
	SW		.26	.13			.05
	LD		.39	.37			.29
	SD		.15	.15			.32
4	BW	.70	.46	.05	.96	.695	<.01
	BF		.61	.76			.43
	LD		.49	.36			.18
	BL		−.06	.03			.10
5	BW	−5.54	.36	.04	.96	.665	<.01
	SW		.23	.14			.10
	LD		.31	.37			.40
	SF		2.18	1.02			.04
	RF		−2.80	1.42			.06
6	BW	−7.98	.32	.05	.96	.666	<.01
	SW		.24	.14			.09
	LD		.35	.37			.35
	SD		.14	.15			.36
	SF		2.07	1.02			.05
	RB		−2.87	1.43			.05
14	BW	−1.71	.41	3.99	.97	.648	<.01
	BL		−.06	.07			.16
	BC		.01	.04			.87
	LC		−.27	.08			.28
	LL		−.17	.24			.43
	SD		.27	.21			.10
	SW		.25	.16			.13
	HW		−.08	.10			.42
	SF		25.88	13.15			.06
	RF		20.57	14.08			.15
	LF		25.23	13.36			.07
	LD		.24	.41			.56
	EW		−.10	.37			.79
	BF		−73.16	40.38			.08

[a]Equations derived by maximum R^2.

[b]BW = body weight, BL = body length, BC = body circumference, LC = front leg circumference, LL = front leg length, SD = shoulder depth, SW = shoulder width, HW = ham width, EW = head width, SF = shoulder fat, RF = last rib fat, LF = last lumbar fat, LD = loin muscle depth, BF = average backfat.

[c]SEE = standard error of estimate.

muscle quantity estimates derived from the NPPC formula, LWTA was overestimated by an average of only .8%. The range of deviations for the individual pigs was from 11.8% less to 12.8% more than the actual LWTA.

A t-test was used to test the partial regression coefficient differences of the Prince et al. (1981) model and the same model from this study. The model included body weight, backfat thickness, loin depth and body length. The standard errors of the partial regression coefficients from this study were used in the calculation of the t statistic. All partial regression coefficients from this study were found to be different ($P<.01$) from the partial regression coefficients derived by Prince et al. (1981).

A similar t-test comparing the regression coefficient difference of the NPPC (1976) formula and the same model from this study was found not to be significantly different.

Resolving the difference from this study and the Prince et al. (1981) study may be explained by the experimental designs. Attempts were made in this study to reduce environmental factors that could influence body composition. Mating type, slaughter weight and litter were not confounded with varying farm factors, so body composition could be predicted by body measurements accurately.

Prediction equations for selected models are presented in table 3. The R^2 ranged from .95, for the one-variable model, to .97 for the 14-variable model. Addition of LD to the three-variable model failed to produce a significant partial regression and did not result in a notable improvement in R^2. The equation that produced the highest R^2 (.96) with significant partial regressions for predicting LWTA was the two-variable model:

$$\text{LWTA (kg)} = -5.19 + .29\ (\text{SW}) + .37\ (\text{BW}).$$

The prediction equation that offers a more practical method of estimating lean quantity in the 15- to 50- kg pig is the one-variable model ($R^2 = .95$):

$$\text{LWTA (kg)} = -1.59 + .44\ (\text{BW}).$$

Predicted kilograms of lean ($\widehat{\text{LWTA1}}$) for individual pigs in the group of additional 24 pigs was calculated using the one-variable model $\widehat{\text{LWTA1}}$ (kg) = −1.59 + .44 (BW). A coefficient of correlation was calculated between LWTA and $\widehat{\text{LWTA1}}$. The variables were found to be highly correlated ($r = .97$). Predicted kilograms of lean ($\widehat{\text{LWTA2}}$) was also calculated using the two-variable model $\widehat{\text{LWTA2}}$ (kg) = −5.19 + .29 (SW) + .37 (BW). The variables $\widehat{\text{LWTA2}}$ and LWTA were also found to be highly correlated ($r = .97$). The high relationships strongly suggest that the results found in this study are useful for predicting LWTA.

Field application of the one-variable model compared with the two-variable model reduces the time and difficulty of taking SW measurements on the live pig. Field application of the one-variable model provides an essential function in lean gain evaluation of swine on a performance test. Estimation of lean quantity in 15- to 50-kg pigs could then be incorporated with procedures for evaluating market pigs by NPPC (1976) and Fahey et al. (1977) or other procedures under development to evaluate lean gain on test.

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