GROWTH AND DEVELOPMENT RELATIONSHIPS TO CARCASS COMPOSITION

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Several years have passed since the National Pork Producers Council published "Procedures to Evaluate Market Hogs", a bulletin designed to provide the pork industry with simplified means of determining carcass composition. Since the procedures outlined in the publication were based on a sample of only 41 carcasses of varying composition (Fahey et al., 1977) and because other similar studies have since been conducted, it is considered essential that these guidelines be reviewed.

The purpose of this presentation is to evaluate certain of these recommendations and to suggest changes where more recent evidence clearly indicates such are in order.

ADJUSTMENT OF MUSCLE PERCENT FOR CARCASS WEIGHT

Although the evaluation bulletin states, "all breed associations and other sponsors should be encouraged to provide awards only when performance data is used in combination with live visual appraisal and carcass information for determining merit", such has not been the case. Numerous state and local shows have used the appropriate formulas to estimate pounds of muscle and divided this value by the hot carcass weight to determine percentage of muscle. This has been the sole criterian used in ranking carcasses that met other carcass requirements.

E. J. Stevermer (1979), Iowa State University Extension Swine Specialist, has evaluated the regression of muscle percent on carcass weight in 9 shows held over the past 2 years. This study based on 1048 carcasses revealed this regression to be -.057% per lb. This indicates that variation in carcass weight could account for differences of nearly 3% in percent muscle among carcasses ranging from 140 - 190 lb. in a carcass show. Since the intent of such competition is to rank carcasses on the basis of equal carcass weight it is recommended that this regression be used to adjust muscle percent to a common weight of 160 to 170 lb.

It should also be emphasized that carcass shows without performance data should not be encouraged. Furthermore, Age Units to 85 lb. of Muscle appears not to be biased by variation in carcass weight so in situations where ranking is on this basis adjustment is not required.

PREDICTION OF POUNDS OF MUSCLE

A study of the Procine Stress Syndrome at Iowa State University yielded as a byproduct carcass measurements that could be used to predict percent muscle in a manner similar to that of the Wisconsin study (Fahey, et al., 1977). The 80 pigs in this study were removed from test at weekly intervals as they attained 240 lb., transported to the meat laboratory where they were sacrificed and subsequently separated into lean, fat, bone and skin.

The results of predicting lb of muscle from these data based on the equation similar to that used in the NPPC procedure are summarized in Table 1. The values used in the NPPC formula are included for comparison. The equation was fitted for each stress group separately and although the values appear somewhat different across the three groups, significant differences were not detected so the results were pooled across the three stress classes

These data suggested that the presently used formula places too much emphasis on carcass weight (.45 vs .28) and backfat thickness (-11.0 vs -7.95). The comparison between the loin eye area regressions (5.0 vs 4.68) failed to yield a significant difference.

The R^2 value from the Wisconsin experiment (.83) is also considerably higher than the .58 value observed in this independent study.

Although these data represent a more restricted sample of the hog population than the original investigation and comprises a much less variable group of carcass weights, the results emphasize the need, as suggested by Dr. Kauffman soon after the original study was completed, to update the procedure when new information is provided.

LOIN EYE CHANGES WITH WEIGHT

Since the inception of the breed certification program an adjustment of .015 square inches of loin muscle area per lb. of live weight has been used to adjust this trait to 220 lb. of live weight. The validity of this procedure has never been tested.

Consideration of this has become paramount since in production tested barrow contests it is not unusual for individuals to exceed 300 lb. in weight Furthermore, on-the-farm ultrasonic testing of animals in excess of 300 lb. has become commonplace. Adjustment of actual values back to 220 or 230 lb. has often resulted in muscle areas below the minimum certification standard have caused producers to ask, "Would my pig's loin eye have been that small when he weighed 230 lb?" or to statements that, "We sure are breeding the muscle out of our pigs!"

We have slaughtered littermate or similarly related pigs at various live weights as a part of numerous growth and development studies at Iowa State University. The findings of these studies are summarized in table 2.

The first study involving 288 pigs, 144 from a cross average in muscling and 144 from a cross considered superior in muscling, revealed a change of .008 sq. in. per lb. in the average group and a .012 sq. in. change in the lean group. These values differ significantly.

Studies 2 and 3 suggest a decrease in the rate of loin eye increase with increasing weight. Changes in muscle area at weights in excess of 260 lb appear to be very slight and considerably below the .015 value currently used for adjustment.

Table 3 summarizes changes in loin eye size as estimated ultrasonically by using loin depth. This study involved 3-breed cross barrows and boars that were fed to weights of 300 lb. These estimates are also below the .015 value currently being used and suggests a declining rate of increase with weight.

In a recently completed study of ultrasonically estimated loin eye area of 8250 boars from 2845 pens, 1554 sires and 46 station-season-years tested in the Iowa Boar Testing Station the regression of loin eye area on live weight was estimated to be $.0153 \pm .0004$. The regression was consistent across the eight breeds tested. No suggestion of a non-linear component was revealed.

These results from boars are difficult to resolve since they disagree with those of the studies cited previously. It is very likely that loin eye change of boars are more linear with weight than those of barrows and gilts because of their later maturity. Also, only one estimate was obtained from each pig and thus any bias resulting from slower growing pigs being measured at lighter weights and faster growing pigs being measured at heavier test weights are not removed.

Since it is apparent that more muscular pigs deposit muscle at a more rapid rate than lighter muscled animals, a formula similar to that recommended for backfat thickness is advised. The recommended formula is as follows:

$$\text{Adjusted LEA} = \text{LEA} + \frac{(230 - \text{wt})\ \text{LEA}}{(\text{wt} + 155)}$$

This formula assumes a pig with a 3 sq. in. loin deposits muscle at the rate of .0078 in. per lb., one with a 4 sq. in. loin area deposits at the rate of .0104/lb, one with a 5 sq. in. loin at a .013 rate, one with a 6 sq. in. eye at a .0156 rate and a 7 sq. in. pig at the rate of .0182/lb. Thus, this adjustment would account for muscling differences between pigs but would not correct for a decreasing rate of deposition with increasing weight.

BACKFAT CHANGES WITH WEIGHT

The adjustment used to account for weight influences on backfat thickness in the breed certification program has been .004 in./lb. This adjustment was not designed to be used for pigs over 240 lb but has been used for this purpose with the advent of production tested barrow shows. It of course assumes linearity of fat deposition and a similar rate of deposition for all pigs regardless of degree of fatness. Neither of these cases are likely to be true.

Robison (1976) presented to this group an extensive review of growth patterns of the pig and concluded backfat deposition to be linear in the range of weights to 287 lb., but that these rates differ for different pigs. He recommended that a pig's own rate of fat deposition be considered when adjusting pigs to a common weight basis.

Experiment I shown in Table 4 presents backfat deposition rates of average and lean crosses between weights of 200 to 250 lb. Although Experiment II suggests an increase in rate of fat deposition with increase in weight, such is not the case in Experiment III or in the barrows evaluated ultrasonically (Table 5). Some evidence for an increased rate of fat deposition with weight increase is boars is suggested by the data presented in Table 5.

An investigation of the weight-backfat relationship in the 8350 boars tested in the Iowa Boar Testing Stations over a five-year period revealed a regression of .0036 ± .00008 in. per lb. This effect was highly significant Although the quadratic influence of weight was highly significant it's inclusion increased the percent of explained variation by only .1%.

The regressions were not detected to be different for the various breeds indicating that a similar adjustment could be used for all breeds.

A plot of the backfat-weight relationship suggested a decline in the rate of fat deposition starting at approximately 225 lb and continuing until approximately 255 lb. At this point the rate of deposition turned abruptly upward. Fitting a three line segments to these data result in a significant increase in R^2 from 57 to 60 percent. The rate of deposition was .0036 ± .0002 up to 225 lb., decreased to .0033 ± .0003 in the 226 -254 lb. range and increased to .0058 ± .0006 at weights above 255 lb.

Although the technique employed constitutes an after-the-fact reasoning it suggests an approach that should be evaluated in further investigations. Cunningham (1977) reported that the sexual stimulation that commonly occurs near 225 lb. with the onset of puberty may surpress the rate of fat deposition during that period. Perhaps this influence was responsible for these results and was followed by a period of rapid deposit at the heavier weights due to a compensating effect and/or the onset of muscle maturity.

Until concrete evidence for a non-linear fat deposition rate is revealed, a linear adjustment that accounts for animal differences should be used. The adjustment recommended by Ahlschwede et al. (1978) where backfat is divided by weight and multiplied times the desired adjustment weight provides an accurate and simple system. It is uncertain whether the slight modification suggested by NSIF is necessary.

COMPOSITION OF PIGS AT THE START OF TEST

When pigs from several sources are weighed on to a performance test actual birth dates are seldom known with equal assurance. One thing that is certain is the weight of the pig on that day. This initial weight can be used as a base from which to compute total muscle deposition during the test period in a manner consistent with that currently recommended by the NPPC procedure. But, it is necessary to know within reasonable limits the porportion of the starting weight of each pig that is comprised of lean. The formula given by the NPPC procedure appears to be inaccurate. What then should be used?

Davey and Bereskin (1977) studying 9 week old pigs chemically analyzed for composition found weight to significantly influence % protein and ether extract. However, the magnitude of this regression was not published. In their study composition of 9-week-old pigs of similar selection background were consistent in composition.

Kauffman (1978) presented plotted data that suggested little if any change in % fat-free muscle between carcasses ranging in weight from 10 to 50 lb. and varying between 50 to 100 days of age.

We have separated 2 lean strain and 2 average strain pigs at 50 lb. live weight and a similar group at 100 lb. Little change was noted with increasing weight. Lean pigs increased from approximately 59.5% to 60.5% lean of carcass weight over this period while average strain pigs remained essentually constant at 58.5%. These values were used to conclude that until more reliable information is presented, a 40% of live weight value provides an adequate estimate of initial composition.

SUMMARY

1. When carcasses are ranked on the basis of estimated percentage of muscle, adjustment must be made for differences in carcass weight.

2. The prediction formula for lb. of muscle currently in use should be re-evaluated and updated if necessary.

3. Loin eye changes are probably not linear with weight increases. A multiplicative adjustment that allows for different rates of changes for pigs differing in muscle content and that provides a decreasing rate of change with increases in weight would best fit the biology involved. Until such an adjustment is developed, a method similar to that recommended by NSIF for adjustment of backfat should be used.

4. Backfat changes with weight appear to be nearly linear with fatter pigs depositing fat at a more rapid rate than leaner pigs. The Nebraska method as modified by NSIF appears to account for the situation. Further studies to varify as to whether an acceleration of deposition occurs at extremes in weight should be conducted.

5. A more accurate means of predicting composition of 40 - 80 lb. pigs is needed. Until such is available using 40% of live weight should suffice since final results are reasonably insensitive to small errors in measurement in initial composition.

References

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TABLE 1

COMPARISON OF REGRESSION VALUES OF THE NPPC FORMULA TO THOSE FROM AN IOWA STATE UNIVERSITY INVESTIGATION.

Source	No. Carcasses	Constant	Regression Values: Carcass Weight	Loin Area	Single Backfat	R^2
NPPC	41	2	.45	5.0	-11.0	.83
Iowa State						
Non-Carriers	27	12.0	.29	4.34*	-8.65	.65
Carriers	32	17.7	.20	5.35**	-4.16	.46
Stress	21	2.1	.38**	4.57**	-14.47**	.63
Pooled	80	11.3	.28**	4.68**	-7.95	.58

* regression significantly different from zero (P<.05)
** regression highly significantly different from zero (P<.01)

TABLE 2.

LOIN EYE AREA CHANGES WITH INCREASES IN LIVE WEIGHT

Expt. No.	No. Pigs	Type	Weight, lb	LEA, $in.^2$	Change/lb in/lb
I	144	Average	200	4.39	
			250	4.79	
	144	Lean	200	5.10	
			2.50	5.72	
II	96	Average	200	4.83	
			230	5.21	
			260	5.29	
III	96	Average	200	4.93	
					.021
			230	5.56	
					.012
			260	5.91	
			290	6.06	

TABLE 3

LOIN EYE MUSCLE AREA CHANGES WITH INCREASE IN LIVE WEIGHT IN BOARS AND BARROWS MEASURED ULTRASONICALLY

No. Pigs	Sex	Weight, lb.	LEA, sq.in.	Change/lb.
36	Barrows	150	4.26	
		200	4.86	
		250	5.26	
		300	5.38	
36	Boars	150	4.20	
			4.79	
			5.25	
			5.55	

TABLE 4

CARCASS BACKFAT CHANGES WITH INCREASES IN LIVE WEIGHT

Expt. No.	No. Pigs	Type	Weight,lb.	B.F. in.	Change/lb.
I	144	Average	200	1.43	
			250	1.73	
		Lean	200	1.23	0048
			250	1.47	
II	96	Average	200	1.31	.0037
			230	1.42	.0086
			260	1.68	
III	96	Average	200	1.29	
			230	1.41	.0053
			260	1.57	
			290	1.69	

TABLE 5

BACKFAT THICKNESS CHANGES WITH INCREASE IN LIVE WEIGHT IN BOARS AND BARROWS MEASURED ULTRASONICALLY

No. Pigs	Sex	Weight, lb.	B.F., in.	Change/lb.
36	Barrows	150	.85	
				.0056
		200	1.13	
		250	1.40	
		300	1.67	
36	Boars	150	.70	
		200	.86	
				.0048
		250	1.09	
				.0056
		300	1.37	