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ESTIMATION OF PIG CARCASS COMPOSITION ON THE BASIS OF A LINEAR AND LOIN EYE AREA MEASUREMENTS

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INTRODUCTION

Presently, pig producers in Poland are paid for the pigs they deliver on the basis of live weight as opposed to the EEC countries system of objective classification of pork carcasses and payment based von the lean meat content. Soon the EEC system are going to be implemented in Poland. To gain approval for the use of the revised EEC Pig Grading Scheme, that was introduced in 1981, methods of estimating carcass lean proportion must be shown to do so with a coefficient of determination (CD) greater than 0.64 (explaining at least 64% of the variance) with a residual standard deviation (RSD) of less than 2.5 on a representative sample of carcasses (EC- Regulations, 1984; 1985).

MATERIALS AND METHODS

Four abattoirs were selected to represent the national kill. Average slaughter capacity of each was approximately 1200 pigs an hour. Overall, 141 pigs were chosen randomly for trials distributed as follows: 26, 35, 40 and 41 in the first, second, third and fourth abattoir respectively. The broad sample of pigs used in the trials represented the ranges of fattiness and weight found nationally. Each day of trials, about 10 pigs were measured, cooled and dissected the following day.

Since it is a commercial practice to partially skin the carcass in most abattoirs in Poland -- the skin is left only on the head, legs, hams and belly -- the left sides were treated conventionally while the skin on the matching right sides were left in tact.

After weighing, the carcasses were moved to the chill coolers and the instrumental measurements were carried out. The Ultra-Meter was used to take fat and muscle depth at the following points:

between the first and second last ribs, 5, 6, 7 and 8 centimetres off the midline;
between the second and third last ribs, 5, 6, 7 and 8 centimetres off the midline;
between the third and fourth last ribs, 5, 6 ,7 and 8 centimetres off the midline; and
between the third and fourth last lumbar vertebra, 5, 6, 7 and 8 centimetres off the midline.

Carcass back tissues were scanned horizontally and longitudinally by ultrasonic heads (CSB Ultra-Meater) at the end of the slaughter line. Video images with cross-sections of fat and muscle areas were stored in both analog and digitized form on the computer's hard disk. The left sides were then cut and calibre measurements taken on the exposed surfaces corresponding with all the ultrasonic measurement sites. The experiment was carried out with both skinned (lard area of skin was removed) and intact carcasses. The depth of back skin removed by the pulling machine in the slaughter line was measured. The skin was weighed before and after removal of any adhering fat. The following day the left sides were cut and on the exposed surfaces corresponding with ultrasonic measurements, the calibre ones were taken. The sides were then separated into component tissues according to a standard IVO method. Area of the rib-eye (*m.longissimus dorsi*) imprints taken during dissections was computed with the help of a planimeter.

RESULTS AND DISCUSSIONS

Leaner Studies

Table 1 shows means, standard deviations and ranges of major traits of skinned carcasses. An average of 141 dissected carcasses lean was 45.3% for pigs with hot weight within the range of 62.8 to 104.2 The results obtained indicate that fat depths taken with the calibre were, on the average, 3.06mm (approximately 13%) smaller than those measured with the Ultra-Meter. The difference in muscle depths was 3.64mm (approximately 8%). Both of these reflects an obvious tendency of tissue to shorten while being chilled in the cooler. There were not significant differences between fat and muscle depths measured at distances 5, 6, 7 and 8cm off the carcass splitting line for both instrumental and calibre traits. Thickest fat cover was at the level between the 3rd/4th last ribs and 3rd/4th lumbar vertebrae: 24.55mm, 25.86mm (Ultra-Meter) and 21.50mm, 23.71mm respectively. The remaining depths at 2nd/3rd and 1st/2nd ribs were: 22.44mm, 22.07mm for Ultra-Meter and 18.64mm, 18.80mm for calibre. Opposite tendency was observed for muscle depths.

It was found that from the correlation studies, there is no single correlation coefficient for both fat and muscle depth exceeding 0.74 (explaining more than 54.8 of total variance) for either calibre or Ultra-Meater measurements. Combining of fat and muscle depth measurements with a calibre produced three equations with a RSD within the range of 2.16 to 2.28 and a CD of 64.3 to 68.7%. No further improvement of accuracy was observed after hot weight of carcasses was introduced as a regressor.

The addition of a second set of measurements (Table 2) contributed significantly to the prediction of lean to such an extent that 16 equations for calibre measurements and five equations for Ultra-Meater were computed. For the latter, the best probing positions were those between the 1st/2nd ribs and the 2nd/3rd ribs 8cm off the midline, where fat and muscle depths together (four variables) predicted lean with a RSD of 2.20 (CD=67.3%). Another equation, combining only three variables (fat and muscle depths between the 1st/2nd ribs and fat depth between the 2nd/3rd ribs), provided lean estimation with a RSD of 2.24 and a CD of 66.3%. Two more equations of sufficient accuracy were found for the combined sites between the 1st/2nd ribs and between the 3rd/4th ribs 8cm off midline but these may introduce unnecessary complexity and could slow the grading operation because the measurements would have to be done twice (after first contact, the ultrasonic head should be moved approximately 9cm up/down to the other probing position while, in the case of the former equation, the distance is about half that, or four to five centimetres). These findings support the results on multiple measurements obtained for the carcass major cuts by Husegge *et al.* (1991).

The results in Table 3 indicate that, in general, for unskinned carcasses, the Ultra-Meater provides significantly less precise prediction of carcass composition than for skinned ones. Only combined probing between the 1st/2nd ribs and the 2nd/3rd ribs 8cm off midline produced an equation based on three variables (fat and muscle depths between the 1st/2nd ribs and fat depth between 2nd/3rd ribs) with a RSD of 2.38 and CD of 64.5%.

Loin Area Studies

Since the areas of loin cross-sections obtained during horizontal scanning and computed by software were not available at the moment, only those taken by tracing with planimeter were used to study the importance of that regressor. The traced areas (approximately 28.7cm2) did not differ significantly. The highest correlation with dissected percent lean (R=0.4914) was found for that between the 1st/2nd ribs. Simulative computations were done where the areas were introduced to the equations along with linear measurements taken both by calibre or by Ultra-Meater. Table 4 shows that it was impossible to find equations when only loin area and fat depth were used. With fat and muscle depths and loin area as independent variables, few equations of sufficient precision were found. The best horizontal probing site for the Ultra-Meater were those between the 1st/2nd ribs 8cm off midline (RSD=2.26; CD 65.7) and between the 2nd/3rd ribs 8cm off midline (RSD=2.26; CD 65.7).

CONCLUSIONS

It was found that skin adversely affects the accuracy of lean estimations. Lean prediction for very fatty pigs was sufficiently accurate to meet EC Pig Grading Scheme criteria only when it was based on dual site ultrasound instrumental measurements of fat and muscle depths between the 1st/2nd ribs and the 2nd/3rd ribs.

Combining the loin area between the 2nd/3rd ribs with fat computed with a planimeter and muscle depths measured instrumentally at that level contributes significantly to the improved accuracy thus producing a single site equation when lean can be estimated with a residual standard deviation of 2.21.

It is probable that further improvement of accuracy of lean meat prediction in pork carcasses would be possible with the inclusion of loin area measurement to the equation. This, however, must be verified on the basis of data obtained from digital images processing.

REFERENCES

EEC. November, 1984. *EC Regulation Nr. 3220/84 for the assessment of the Community scale for grading pig carcasses.* 3pp.

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HUSEGGE, B., STERRENBURG, P., and MEERKUS, G.S.M. 1991. Estimation of EC-lean meat percentage in major cuts of pig carcasses based on multiple measurements of fat thickness with the Hennesy Grading Probe 2. *Proc. 37th ICMST.* Kulmbach, Germany.

Table 1. Means, standard deviations and ranges of major traits of skinned carcasses.

Mean	Standard Deviation	Minimum	Maximum	N	Label
80.79	9.92	62.77	104.24	141	Hot weight
45.30	3.81	38.67	56.57	141	% Lean
33.60	4.70	18.09	42.33	141	% Total Fat
9.44	2.12	3.56	14.53	141	% Subcutaneous Fat

Table 2. Residual standard deviations and percent variance explained for the equations predicting skinned carcass lean meat percentage based on Ultra-Meater and calibre measurements from two sites.

CALIBRE

Sites of measurement (between ribs)	5cm off the midline	6cm off the midline	7cm off the midline	8cm off the midline
2nd/3rd ribs (fat, muscle) + 3rd/4th ribs (fat)	2.63 54.0%	2.46 59.1%	2.36 62.6%	2.39 61.6%
2nd/3rd ribs (fat) + 3rd/4th ribs (fat, muscle)	2.53 57.3%	2.40 61.1%	2.24 66.4%*	2.31 64.0%*
2nd/3rd ribs (fat, muscle) + 3rd/4th ribs (fat, muscle)	2.53 57.4%	2.40 61.5%	2.23 66.4%*	2.31 64.1%*
1st/2nd ribs (fat, muscle) + 3rd/4th ribs (fat)	2.58 54.3	2.32 62.9%	2.14 68.5%*	2.09 70.6%*
1st/2nd ribs (fat) + 3rd/4th ribs (fat, muscle)	2.45 58.9%	2.30 63.5%	2.14 68.4%*	2.26 65.9%*
1st/2nd ribs (fat, muscle) + 3rd/4th ribs (fat, muscle)	2.41 60.2%	2.22 66.0%*	2.05 70.9%*	2.08 70.9%*
1st/2nd ribs (fat, muscle) + 2nd/3rd ribs (fat)	2.59 55.2%	2.35 62.8%	2.17 68.5%*	2.15 68.9%*
1st/2nd ribs (fat) + 2nd/3rd ribs (fat, muscle)	2.58 55.6%	2.41 61.0%	2.31 64.0%*	2.34 63.3%
1st/2nd ribs (fat, muscle) + 2nd/3rd ribs (fat, muscle)	2.53 57.2%	2.32 63.6%	2.16 68.6%*	2.16 68.7%*

Table 2 (cont). Residual standard deviations and percent variance explained for the equations predicting skinned carcass lean meat percentage based on Ultra-Meater and calibre measurements from two sites.

ULTRA-MEATER

Sites of measurements (between ribs)	5cm off the midline	6cm off the midline	7cm off the midline	8cm off the midline

2nd/3rd ribs (fat, muscle) + 3rd/4th ribs (fat)	2.44 59.8%	2.50 57.5%	2.52 57.2%	2.42 60.7%
2nd/3rd ribs (fat) + 3rd/4th ribs (fat, muscle)	2.49 58.0%	2.59 54.4%	2.52 56.9%	2.43 60.1%
2nd/3rd ribs (fat, muscle) + 3rd/4th ribs (fat, muscle)	2.41 60.7%	2.49 57.7%	2.47 58.6%	2.36 62.3%
1st/2nd ribs (fat, muscle) + 3rd/4th ribs (fat)	2.62 53.7%	2.54 56.5%	2.43 59.9%	2.31 64.2%*
1st/2nd ribs (fat) + 3rd/4th ribs (fat, muscle)	2.54 56.4%	2.54 56.7%	2.52 57.3%	2.47 58.6%
1st/2nd ribs (fat, muscle) + 3rd/4th ribs (fat, muscle)	2.52 57.1%	2.49 58.5%	2.41 60.8%	2.28 64.7%*
1st/2nd ribs (fat, muscle) + 2nd/3rd ribs (fat)	2.57 55.2%	2.51 57.5%	2.43 60.3%	2.24 66.3%*
1st/2nd ribs (fat) + 2nd/3rd ribs (fat, muscle)	2.44 59.7%	2.34 63.0%	2.45 59.7%	2.31 64.0%*
1st/2nd ribs (fat, muscle) + 2nd/3rd ribs (fat, muscle)	2.45 59.7%	2.34 62.8%	2.41 61.0%	2.20 67.3%*

* Means statistics for the equations meeting EEC requirements

Table 3. Residual standard deviations and percent variance explained for the equations predicting unskinned carcass lean meat percentage based on the Ultra-Meater measurements for two sites.

CALIBRE

Sites of measurements (between ribs)	5cm off the midline	6cm off the midline	7cm off the midline	8cm off the midline
2nd/3rd ribs (fat, muscle) + 3rd/4th ribs (fat)	2.62 57.0%	2.70 54.1%	2.61 57.4%	2.54 59.9
2nd/3rd ribs (fat) + 3rd/4th ribs (fat, muscle)	2.71 54.1%	2.86 48.8%	2.72 54.0%	2.66 55.9%

2nd/3rd ribs (fat, muscle) + 3rd/4th ribs (fat, muscle)	2.64 56.4%	2.70 54.4%	2.62 56.9%	2.56 59.1%
1st/2nd ribs (fat, muscle) + 3rd/4th ribs (fat)	2.73 53.6%	2.77 52.5%	2.62 57.3%	2.51 60.9%
1st/2nd ribs (fat) + 3rd/4th ribs (fat, muscle)	2.76 52.6%	2.84 49.7%	2.78 51.9%	2.76 52.6%
1st/2nd ribs (fat, muscle) + 3rd/4th ribs (fat, muscle)	2.81 50.7%	2.78 51.9%	2.62 57.1%	2.51 60.7%
1st/2nd ribs (fat, muscle) + 2nd/3rd ribs (fat)	2.65 56.3%	2.62 57.1%	2.58 58.2%	2.38 64.5%*
1st/2nd ribs (fat) + 2nd/3rd ribs (fat, muscle)	2.65 56.3%	2.62 57.1%	2.64 56.5%	2.52 60.5%
1st/2nd ribs (fat, muscle) + 2nd/3rd ribs (fat, muscle)	2.76 52.4%	2.75 52.8%	2.61 57.4%	2.42 63.4%

* Means statistics for the equations meeting EEC requirements.

Table 4. Residual standard deviations and percent variance explained for the equations predicting skinned carcass lean meat percentage based on Ultra-Meater and calibre single site measurements including area of the LD (computed with planimeter).

CALIBRE

Site of measurement	6cm off the midline	7cm off the midline	8cm off the midline
1st/2nd ribs:			
fat	2.69; 50.1%	2.62; 52.8%	2.61; 54.2%
fat, muscle	2.33; 62.6%	2.17; 67.7%*	2.16; 68.7%*
fat, area of LD	-- --	— —	— —
fat, muscle, area of LD	2.20; 66.7%*	— —	2.13; 69.5%*
2nd/3rd ribs:			
fat	2.77; 48.5%	2.69; 51.3%	2.73; 49.9%
fat, muscle	2.47; 58.8%	2.89; 61.7%	2.46; 59.3%
fat, area of LD	— —	— —	— —
fat, muscle, area of LD	2.40; 60.4%	2.36; 62.7%	— —
3rd/4th ribs:			
fat	2.89; 42.4%	2.84; 44.5%	2.79; 47.8%
fat, muscle	2.44; 59.0%	2.28; 64.3%	2.36; 62.6%
fat, area of LD	— —	— —	— —
fat, muscle, area of LD	2.40; 60.4%	— —	2.31; 64.0%
3rd/4th lumbar vertebrae:			
fat	2.45; 46.4%	2.80; 46.3%	2.81; 47.4%
fat, muscle	2.51; 57.1%	2.51; 57.1%	2.52; 57.8%
fat, area of LD	— —	— —	— —
fat, muscle, area of LD	2.45; 59.0%	2.45; 58.9%	2.45; 59.8%

* Means statistics for the equations meeting EEC requirements

Table 4 (cont). Residual standard deviations and percent variance explained for the equations predicting skinned carcass lean meat percentage based on Ultra-Meater and calibre single site measurements including area of the LD (computed with planimeter).

ULTRA-MEATER

Site of measurement	6cm off the midline	7cm off the midline	8cm off the midline
1st/2nd ribs:			
fat	2.69; 45.3%	2.83; 46.0%	2.67; 51.4%
fat, muscle	-- --	-- --	2.35; 62.8%
fat, area of LD	2.44; 60.0%	2.47; 58.9%	-- --
fat, muscle, area of LD	2.38; 62.2%	2.39; 61.4%	2.26; 65.7%*
2nd/3rd ribs:			
fat	2.87; 44.2%	2.84; 45.3%	2.69; 51.4%
fat, muscle	2.49; 57.7%	-- --	2.42; 60.6%
fat, area of LD	-- --	2.59; 55.0%	-- --
fat, muscle, area of LD	2.45; 59.2%	2.50; 57.8%	2.31; 64.0%*
3rd/4th ribs:			
fat	3.03; 37.8%	2.92; 42.8%	2.90; 43.5%
fat, muscle	-- --	-- --	-- --
fat, area of LD	2.73; 49.9%	2.63; 53.5%	2.60; 54.4%
fat, muscle, area of LD	2.67; 52.0%	2.53; 56.8%	2.52; 57.3%
3rd/4th lumbar vertebrae:			
fat			
fat, muscle	3.02; 38.8%	2.96; 40.8%	3.01; 39.3%
fat, area of LD	-- --	-- --	-- --
fat, muscle, area of LD	2.68; 51.9%	2.64; 53.5%	2.73; 50.4%
	2.62; 54.0%	2.53; 57.2%	2.67; 52.8%

* Means statistics for the equations meeting EEC requirements