S4P01.WP

PREDICTION OF LEAN MEAT YIELD BY REAL-TIME ULTRASOUND IN BARROWS, BOARS AND GILTS OF FOUR DIFFERENT PURE BREEDS

C.A. AKER[1,2], R.O. BALL[1], R.A. KEMP[1,2] and B.E. UTTARO[1]

1 Department of Animal and Poultry Science, University of Guelph Guelph, Ontario, Canada

2 Animal Industry Branch, Ontario Ministry of Agriculture and Food, Guelph, Ontario, Canada

INTRODUCTION

Real-time ultrasound is an advanced form of ultrasonics that can depict cross-sectional images of moving structures. In recent years, real-time ultrasound has been evaluated by the livestock industry as a means of predicting carcass composition in the live animal. Although the use of real-time ultrasound has met with limited success in the beef and sheep industries, a number of studies to date indicate it has the potential to make a contribution to breeding and selection programs in the swine industry.

To date, most studies have examined the relationships between various carcass characteristics measured by real-time ultrasound and the comparable measures made on the carcass. As such, the technology is being used to predict measures that are themselves predictors of carcass composition. A more accurate evaluation of the technology should assess its ability to predict the actual lean meat content of a carcass. Allen (1990) states that for most applications, the utility of ultrasonic machines lies in their ability to predict carcass lean content from a combination of live weight and ultrasonic measurements rather than to predict carcass measurements per se.

The Ontario Swine Improvement Program is a genetic evaluation program that provides estimates of a pig's breeding value for growth rate and backfat thickness. The program uses two sites for ultrasonic determination of backfat thickness on live pigs -- the mid-back and loin. These sites differ from the current Canadian carcass grading site which is located between the 3rd and 4th last rib, therefore, the carcass grading site should be compared to the current live animal sites.

The current study was undertaken to evaluate the usefulness of real-time ultrasound in the prediction of carcass lean meat yield in a large population of purebred pigs. In addition, a comparison was made of four different ultrasound probe sites to assess their ability to predict lean meat yield.

MATERIALS AND METHODS

The data were collected on 592 purebred Yorkshire, Landrace, Duroc and Hampshire pigs evaluated through the Ontario Pork Carcass Appraisal Project. All pigs were evaluated at the provincial central test station during the period May, 1991 to July, 1992. Four pigs from the same litter (one gilt, one barrow and two boars) were submitted from participant herds and started on test at an average weight of 30kg. Litters were housed in two randomly allocated pens with the gilt and barrow in one pen and two boards in the other. All pigs were fed *ad libitum* a corn-soybean based diet with a minimum 18.5% crude protein. Within seven days prior to slaughter at approximately 100kg live weight (range 91 to 121kg), pigs were probed using the SSD-210DXII Aloka Echo Camera. The probe sites included the shoulder, 3rd/4th last rib, mid-back (last rib) and the loin (15cm posterior to the last rib). Fat depth (FD), muscle depth (MD), and muscle area (MA) were recorded at all sites except the shoulder where fat depth was the only variable measured for a total of ten ultrasound measurements.

All pigs were slaughtered at a commercial abattoir. Carcasses were split, chilled overnight and the left side transported to the University of Guelph Meat Laboratory for dissection. Three primal cuts (shoulder, loin and ham) were physically separated into lean, fat and bone, following the guidelines of the Agriculture Canada Livestock and Poultry Products Division Pork Carcass Cutability Specification Guide. Carcass lean meat yield was calculated from the lean separated from the shoulder, loin and ham primals as a proportion of the total weight of the three primals. The lean yield of each of the primal cuts was determined from the lean separated from that cut expressed as a proportion of the primal weight.

Stepwise multiple liner regression produced a four-variable model (FD, MD and MA at the $3^{rd}/4^{th}$ last rib and FD at the loin site) to predict carcass lean meat yield with no further improvement by addition of other variables. The data were analyzed by the method of least squares using a general liner models procedure (SAS, 1985). The reduced statistical model, based upon elimination of non-significant effects and interactions ($P>0.1$), included the fixed effects of sex, breed, replicate, breed by replicate interaction and date of ultrasound probing within replicate. The final model also included live weight at slaughter as a covariate and the four ultrasound measurements as regression variables. The R^2 and RSD produced by the four variable regression model were 0.71 and 2.00; these improved to 0.82 and 1.79 following addition of the fixed effects and covariates. The model was employed separately for breed and sex, with appropriate adjustments, to evaluate its ability to predict carcass lean meat yield in different populations. Simple correlation coefficients between real-time ultrasound measurements and lean meat yield in the carcass and primal cuts were also determined.

RESULTS AND DISCUSSION

Least squares means for carcass lean meat yield and lean yield of the primal cuts, by breed and sex, are presented in Table 1. Significant differences were observed between the breeds for all traits except loin lean yield. These data indicate differences in the distribution of lean yield between the primal cuts. The greatest differences were observed in the ham lean yield. Sex differences were significant for all traits except shoulder lean yield. All other traits showed the same trend with boars having the highest percent of lean meat and barrows the lowest. Sex differences were most pronounced for loin lean yield. Overall, differences in lean yield were greater between sexes than between breeds.

The percentage of variance explained (R^2) and the residual standard deviation (RSD) for carcass lean yield determined by the models used are shown in Table 2. Intercepts and regression coefficients are also presented. The R^2 and RSD for the overall model were 0.82 and 1.79, respectively (Table 2). The addition of other possible variables did not result in any appreciable improvements in the model. This R^2 is higher than the range of 0.70 to 0.76 reported by Sather *et al.* (1990) for models incorporating one, two or four ultrasound measures. Kanis *et al.* (1986) reported a range of R^2 values of 0.50 to 0.68 (RSD 1.8 to 2.4%) for the prediction of lean parts percentage by combining live weight and fat depth at two or more positions. Busk (1986) described a four variable model combining one measure of muscle thickness and three measures of fat thickness with an R^2 of 0.76 (RSD 1.22).

The present model is based on ultrasonic measurements at two difference locations -- the 3rd/4th last rib and the loin. Removing the loin fat measurement from the model results in a relatively minor reduction in the predictive ability of the model ($R^2$0.80; RSD 1.88) and would simplify the probing procedure by eliminating the need to scan a second location.

Percentage of variation explained (R^2) and the residual standard deviations (RSD) are also presented in Table 2 by breed and sex. The RSD in the Hampshire population is considerably higher than that reported for the other three breeds. This is probably the result of insufficient numbers of observations in this population. Otherwise, differences in R^2 and RSD values between breeds were small, as were the differences between the sexes. These differences can probably be explained by differences in variation within breeds and sexes, rather than differences in the predictive ability of the model due to breed and sex per se. Given this argument, the overall model could be used to predict carcass lean yield in all breeds and sexes with reasonable accuracy.

Phenotypic correlations (Table 3) show that fat measurements by live ultrasonic techniques were most highly correlated with carcass lean yield and lean yield or primal cuts. All but five of the correlations were significantly different from zero. These correlations are comparable with those reported by Kanis *et al.* (1986) who found a range of -0.57 to -0.79 for ultrasonic backfat measurements taken at various sites and lean parts as a percentage of cold carcass weight. Correlations between muscle depth and lean yield were low for all sites and mostly not significantly different from zero, whereas muscle area at two of the three measurement sites (3rd/4th last rib and last rib) was moderately correlated with lean yield of the carcass and primal cuts. Forrest *et al.* (1989) reported higher correlations between ultrasonic fat thickness measurements and carcass lean standardized to 10% fat content than muscle area measurements recorded at the same sites. These data indicate that fat measurements by themselves are related to lean yield in the carcass and primal cuts (with the exception of the shoulder), whereas muscle area and muscle depth are not.

Although there is some controversy in the literature, the present study supports the use of muscle measurements to improve the accuracy of prediction of lean yield, when combined with measurements of fat thickness, based upon an increase in the R^2 value. Newman and Wood (1989) reported a comparable improvement in R^2 by the addition of muscle depth to fat depth at the same location, whereas Alliston *et al.* (1982) found that precision was not improved by the addition of muscle area to fat thickness measurements.

Loin fat measurements (3rd/4th last rib, last rib and loin) were more highly correlated with lean yield in the carcass and all primal cuts than the shoulder fat measurement. The correlation between shoulder fat depth and lean yield of the shoulder was lower than for other cuts, indicating a poorer relationship between fat depth and lean yield of cuts in this portion of the carcass. Conversely, all measures of fat depth on the loin were highly correlated with the lean yield of the loin and carcass.

Sather *et al.* (1990) reported that the current Canadian Swine Improvement Program sites (mid back and loin) were more precise than the carcass grading site for the prediction of the proportion of lean or fat in four lean cuts in the live pig. The present study shows that fat depth measured at the 3rd/4th last rib was at least as well correlated with lean yield in the loin and carcass as fat depth measured at the other two sites. This contradiction may be due to sampling of different populations of Canadian pigs.

CONCLUSIONS

Real-time ultrasound technology may have a role in improving genetic selection programs for carcass composition. Approximately 82% of the variation in carcass lean yield could be explained by a model that included the variables of fat depth, muscle depth and muscle area at the 3rd/4th last rib, and fat depth at the loin and fixed effects of breed, sex, replicate, breed x replicate, date of ultrasound probing within replicate and the covariate live weight at slaughter.

Small differences were noted in the R^2 and RSD values when the model was employed within breeds and sexes. This was attributed to differences in the amount of variation within breeds and sexes, rather than differences due to breed and sex per se.

Real-time ultrasound measurements taken at the current grading site (3rd/4th last rib) were as highly correlated with carcass lean yield as measurements taken at either of the current sites used in Canada.

REFERENCES

ALLEN, P. 1990. New approaches to measuring body composition in live meat animals. In: WOOD, J.D., and FISHER, A.V. (eds). *Reducing Fat in Meat Animals.* Elsevier Science Publishing Company Ltd., New York, pp.201-254.

ALLISTON, J.C., KEMPSTER, A.J., OWEN, M.G., and ELLIS, M. 1982. An evaluation of three ultrasonic machines for predicting the body composition of live pigs of the same breed, sex and live weight. *Anim. Prod.* 35:165-169.

BUSK, H. 1986. Testing of 5 ultrasonic equipments for measuring of carcass quality on live pigs. *World Review Anim. Prod.* 22(3):35-38.

FORREST, J.C., KUEI, C.H., ORCUTT, M.W., SCHINKEL, A.P., STOUFFER, J.R., and JUDGE, M.D. 1989. A review of potential new methods of on-line pork carcass evaluation. *J. Anim. Sci.* 67:2164-2170.

KANIS, E., VAN DER STEEN, H.A.M., DE ROO, K., and DE GROOT, P.N. 1986. Prediction of lean parts and carcass price from ultrasonic backfat measurements in live pigs. *Livestock Prod. Sci.* 14:55-64.

NEWMAN, P.B., and WOOD, J.D. 1989. New techniques for assessment of pig carcasses--video and ultrasonic systems. New Techniques in Pig Carcass Evaluation--Proceedings of the EAAP--symposium of the Commission on Pig Production, July, 1988, pp.37-51.

SAS INSTITUTE, INC. 1985. *SAS User's Guide: Statistics.* 5th Edition. SAS Inst. Inc., Cary, NC.

SATHER, A.P., NEWMAN, J.A., JONES, S.D.M., TONG, A.K.W., ZAWADSKI, S.M., and COLLPITTS, G. 1990. Evaluation of live pigs using mode-A and mode-B ultrasonic probe technologies. *Lacombe Research Station Annual Report.* Lacombe, Alberta.

Table 1. Least squares means (±SEM) for % lean yield of the carcases and primal cuts.

Variable	N	% Lean Yield Carcass	Loin	Ham	Shoulder
Breed					
Yorkshire	294	52.87[a] ± 0.14	50.17 ± 0.25	62.87[a] ± 0.17	47.31[a] ± 0.23
Landrace	165	52.67[ab] ± 0.18	49.93 ± 0.20	61.27[ab] ± 0.22	46.59[b] ± 0.18
Durco	86	52.06[b] ± 0.23	49.67 ± 0.32	61.23[b] ± 0.28	45.89[bc] ± 0.29
Hampshire	47	52.16[b] ± 0.31	49.63 ± 0.43	61.22[b] ± 0.38	45.82[c] ± 0.39
Sex					
Boar	151	53.06[x] ± 0.22	51.04[x] ± 0.30	62.38[x] ± 0.27	46.52 ± 0.28
Gilt	226	52.41[y] ± 0.17	49.76[y] ± 0.24	61.56[y] ± 0.21	46.35 ± 0.22
Barrow	215	51.85[z] ± 0.17	48.74[z] ± 0.24	61.01[z] ± 0.21	46.34 ± 0.22

[a,b,c] Breed means within columns with different superscripts differ (P<0.05).
[x,y,z] Sex means within columns with different superscripts differ (P<0.05).

Table 2. Percentage of variation explained (R^2) and residual standard deviation (RSD) in carcass lean yield determined by real-time ultrasound measurements.

Variable	Int.	b_1	b_2	b_3	b_4	R^2	RSD
Overall[a]	55.05	-0.41	1.00	0.10	-0.30	0.82	1.79
Breed[b]							
Yorkshire	60.72	-0.41	1.17	0.09	-0.33	0.85	1.72
Landrace	45.52	-0.38	0.81	0.18	-0.31	0.82	1.91
Durco	61.68	-0.58	0.86	0.07	-0.18	0.88	1.89
Hampshire	60.25	-0.50	0.25	-0.04	-0.12	0.83	2.61
Sex[c]							
Boar	55.63	-0.42	1.15	0.17	-0.28	0.87	1.73
Gilt	63.60	-0.43	1.22	-0.03	-0.33	0.84	1.73
Barrow	52.75	-0.43	0.69	0.13	-0.24	0.85	1.87

b_1 coefficient for fat depth at 3rd/4th last rib
b_2 coefficient for loin eye area at 3rd/4th last rib
b_3 coefficient for muscle depth at 3rd/4th last rib
b_4 coefficient for fat depth at loin
[a] model also included the fixed effects of sex, breed, replicate, breed x replicate, date of ultrasound probing within replicate and live weight at slaughter
[b] breed effects removed from model
[c] sex effects removed from model

Table 3. Simple correlations between live ultrasound measurements and % lean yield of the carcass and primal cuts (n=592).

	% Lean Yield			
	Carcass	Lion	Ham	Shoulder
Shoulder fat depth	-0.59**	-0.58**	-0.54**	-0.36**
3rd/4th last rib				
fat depth	-0.79**	-0.80**	-0.69**	-0.48**
muscle depth	0.26**	0.22**	0.30**	0.12*
muscle area	0.48**	0.37**	0.39**	0.46**
Mid-back (last rib)				
fat depth	-0.77**	-0.79**	-0.71**	-0.44**
muscle depth	0.00	0.15**	0.27**	0.05
muscle area	0.45**	0.34**	0.40**	0.43**
Loin				
fat depth	-0.76**	-0.77**	-0.70**	-0.45**
muscle depth	0.00	0.06	0.11	-0.21**
muscle area	0.21**	0.23**	0.20**	0.05

** P<0.0001; * P<0.0005.