Evaluation of the Magnitude of Ractopamine Treatment Biases When Fat-Free Lean Mass is Predicted by Commonly Used Equations

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Introduction

Numerous research trials have been conducted which have evaluated the impact of ractopamine (RAC) to alter carcass composition. In most trials, the carcass composition of pigs fed RAC was predicted using equations developed from pigs not fed RAC. Substantial biases have been found in the prediction of the fat-free lean mass of pigs fed RAC (Gu et al., 1992). The objective of this study was the evaluation of the effect of RAC, dietary lysine, and crude protein (CP) on the prediction of carcass fat-free lean mass using alternative prediction equations.

Materials and Methods

The 45 barrows used were part of an experiment designed to evaluate the effects of dietary lysine and crude protein levels while feeding RAC (Paylean™, Elanco Animal Health) on growth performance and carcass traits (Herr et al., 2000). Barrows (PIC 337 sires by C22 dams) were allotted at 153 lb BW to three dietary treatments. The treatments were: 1) 16% CP (0.82% lysine) control diet (CON); 2) 16% CP, (0.82% lysine) with 20 ppm RAC (RAC16); and 3) a crude protein phase feeding sequence containing 20 ppm RAC (RAC-P) consisting of 18% CP (1.08% lysine) during weeks one and four, 20% CP (1.22% lysine) during weeks two and three, 16% CP (0.95% lysine) during week five, and 16% CP (0.82% lysine) during week six.

Slaughter procedures. Pigs were removed when the mean of their experimental block reached 240 lbs. The afternoon prior to slaughter, pigs were weighed (on farm) and live animal B-mode ultrasound (Aloka Model 500V Real-Time Ultrasound, Corometrics Medical Systems, Wallingford, CT) measurements were taken for backfat depth, 3 in off-midline, at the tenth rib (UBF) and last rib (UBFL). Ultrasonic measurements of the loin eye area were also taken at the tenth rib (ULEA). Fifteen pigs per treatment were transported to the Purdue University Meat Science Laboratory. The pigs were stunned, immediately exsanguinated, and then scalded and mechanically dehaired.

Both sides were placed in a 35°F chilling unit for 24 h before further carcass measurements were taken. Backfat thickness, including skin, was measured with a ruler over the midline opposite the last rib. The right side of each carcass was ribbed between 10th- and 11th-rib positions prior to fabrication. Loin eye area and fat depth measurements (three-quarters of the length of the transverse section of the exposed Longissimus muscle) were taken between the 10th and 11th ribs.

The right side of each carcass was fabricated into trimmed wholesale cuts. The ham, loin, Boston butt, and picnic were individually dissected into lean, fat, bone, and skin. The dissected lean and fat tissue from the other cuts (belly, spare ribs, jowl, neckbone, tail, and lean and fat trimmings) were pooled. A 1 lb fat tissue sample was obtained from the other cuts (belly, spare ribs, jowl, neckbone, and tail) proportional to their weight. The lipid content of the dissectible lean from the four lean cuts (ham, loin, picnic, and Boston butt), pooled dissected fat, other cut soft tissue, and other cut fat sample were determined.

The percentage of inseparable fat tissue in the dissected lean of the four lean cuts and other cut soft tissue was predicted by dividing the percentage of lipid in the dissected lean of the four lean cuts and other cut soft tissue (CL%) by the percentage of lipid in the pooled dissected fat sample (CLT%) or other cut fat sample. Calculation of fat-free lean mass (FFLM) of each of the two carcass components (dissected lean from the four lean cuts and other cut soft tissue) was determined with the following equation: FFLM = DLM [1 - (CL%/CLT%)], where DLM was dissected lean or other soft tissue mass. Total carcass FFLM was estimated as the sum of the FFLM of each of the four lean cuts and other cut soft tissue.

Statistical analysis. Regression equations for predicting the mass of the carcass composition end point measures were developed using the GLM procedure of SAS (Schinckel et al., 2003). Independent variables, included in multiple regression equations, were grouped according to the type of measurements used (i.e., midline ruler, ribbed carcass, live ultrasonic scanning, and partial dissection). Four sets of alternative prediction equations were also evaluated: 1) equations from the Purdue lean growth trial (Schinckel et al., 2001); 2) National Pork Producers Council, 1991; 3) National Pork Board, 2000; and 4) National Pork Board 2002.

The accuracy of each prediction equation was evaluated by the multiple coefficient of determination (R^2) and by the residual standard deviation (RSD). Least square means of the residual values for the three treatments yield estimates of subpopulation biases (Gu et al., 1992). The predicted differences between RAC16 and control pigs, and between the RAC-P and control pigs were compared to the actual treatment differences in FFLM.

Results

Acronyms, definitions for variables, overall means, and diet treatment means are given in Table 1. The standard deviations for live weight and carcass weight (10.7 and 9.2 lbs) were smaller than in past pork carcass composition trials, as termination occurred when a mean block weight of 240 lbs was achieved. The dietary RAC and lysine treatments significantly affected the carcass FFLM and FFL percentage. The RAC-P barrows had the greatest FFLM, the RAC16 pigs were intermediate, and the CON pigs had the least amount of FFLM. The RAC-P barrows had lower percent lipid in the other cut soft tissue than the CON and RAC16 barrows. In addition, percent lipid in the dissected lean was less for the RAC-P barrows than for the RAC16 and CON barrows. The RAC-P barrows had less ultrasonic last rib, ultrasonic tenth rib, and carcass tenth rib backfat thickness than the CON and RAC16 barrows, which had similar values for each of the variables. There were no treatment differences from midline last rib backfat thickness.

The increase in FFLM of the RAC16 and RAC-P pigs over the control pigs was 6.74 and 15.69 lbs, respectively. The predicted difference between the RAC-treated pigs and control pigs is presented in Table 2. Equations including carcass weight and midline last rib backfat depth only detected 15.4 to 17.8% of the actual difference in FFLM between the RAC16 pigs and the control pigs, and 29.1 to 32.7% of the actual difference between the RAC-P and control pigs. Equations including standard ribbed carcass measurements accounted for 44.8 to 56.7% (mean 51.1%) of the actual differences between the RAC-treated and control pigs. The percent of control versus RAC treatment differences accounted for by the alternative live animal ultrasound equations averaged 44.2% with a range of 22.3 to 57.7 %. The percentages of RAC treatment differences accounted for by the alternative equations including the same measurements were similar.

Discussion

The first objective of this research was to evaluate the magnitude of prediction biases of alternative carcass composition endpoints when RAC was fed. From a practical perspective, biases occur when different subpopulations have different values of lean mass at the same values of the independent variables (Gu et al., 1992; Hicks et al., 1998). Subpopulation differences in the proportional mass of lean and fat tissues and the chemical composition of the lean and fat tissues are partially responsible for subpopulation biases (Gu et al., 1992; Schinckel et al., 2001). Prediction biases will likely cause producers marketing RAC pigs to only receive partial payment for the increased carcass cut out value produced by RAC. In addition, prediction biases will add additional "measurement method" variation on the predicted carcass value of RAC-fed pigs. This research indicates that all recently developed prediction equations have a similar magnitude of biases regarding RAC. The prediction equation developed from the original data was biased and comprised of both control and pigs fed RAC. Research should not be targeted to identify a constant value that should be added for "RAC-fed" pigs. The impact of RAC to alter carcass composition is dependent on the RAC concentration fed, the duration of use, and the dietary lysine (CP) concentration fed. The economic return for increased leanness of the producers' pigs will determine the optimal dietary RAC and lysine concentrations.

Fat-free lean gain has been extensively used to predict lysine requirements (Schinckel and DeLange, 1996). Prediction equations developed from pigs not fed RAC would have under-predicted the FFLM of the RAC-P pigs by 7.4 lb based on real-time ultrasound measurements and 7.2 lb based on standard ribbed carcass measurements. These equations under-predicted FFLM gain by approximately 0.19 lb/day. Essentially, the use of either real-time ultrasound or ribbed carcass measurements would predict approximately 50% of the increase in daily FFLM gain. This would result in diets being fed which would be expected to allow only approximately 50% of the RAC response to increase FFLM to be achieved. Researchers whose objective is to evaluate accurately the impact of RAC on carcass component mass and growth should consider additional measurements based on partial dissection or chemical analyses. The incorporation of dissected ham lean had a slightly greater impact than dissected loin lean to reduce prediction biases. The only other means reported to predict precisely the response to RAC is the use of total body electrical conductance (TOBEC) in combination with carcass weight and a measure of tenth rib backfat depth (Gu et al., 1992).

Applications

All alternative prediction equations from easily obtained carcass measures only partially predict the true effect of RAC to increase carcass leanness. The dietary lysine and crude protein levels fed affected the magnitude of the RAC response and biases. Researchers wanting to predict accurately the compositional growth of RAC-fed pigs should consider some partial carcass dissection, chemical analyses, or alternative technologies. Marketing systems utilizing carcass measurements to predict lean mass will only account for 15 to 57% of the increased lean mass and value of RAC-fed pigs.

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Table 1. Overall and treatment means for pigs fed ractopamine and different lysine levels

				Treatment LS means			
	Acronym	**Mean**	**SD**	**Control**	**RAC16**	**RAC-P**	**SE**
Live weight, lb	LW	251.8	10.7	248.8	250.9	253.5	2.6
Carcass weight, lb	CW	192.9	9.2	190.2^{a}	191.2^{a}	197.4^{b}	2.2
Fat-free lean mass, lb	FFLM	94.29	8.8	86.82^{a}	93.56^{b}	102.51^{c}	1.5
Fat-free lean percentage	FF%	48.85	3.6	45.67^{a}	48.91^{b}	51.96^{c}	0.65
Ultrasonic last rib backfat depth, in	UBFL	0.56	0.11	0.61^{a}	0.58^{a}	0.50^{b}	0.03
Ultrasonic tenth rib backfat depth, in	UBF	0.68	0.16	0.71^{a}	0.74^{a}	0.59^{b}	0.04
Ultrasonic tenth rib loin muscle area, in^{2}	ULEA	6.84	0.63	6.48^{a}	6.94^{b}	7.09^{b}	0.15
Carcass fat depth, tenth rib, in	FD10R	0.66	0.17	0.74^{a}	0.64^{b}	0.61^{b}	0.04
Carcass loin muscle area, tenth rib, in^{2}	LEA	7.44	0.81	7.04^{a}	7.37^{a}	7.92^{b}	0.26
Carcass midline last rib backfat depth, in	BFLR	0.82	0.14	0.83	0.84	0.78	0.04
Percent lipid in other cut soft tissue	PLIPOC	26.9	5.3	29.4^{a}	27.9^{a}	23.4^{b}	1.2
Percent lipid in the dissected fat	%LIPFAT	62.9	0.89	63.1^{ab}	65.0^{a}	60.6^{b}	0.96
Percent lipid in the dissected lean	%LIPDL	5.03	4.1	5.26^{a}	5.39^{a}	4.44^{b}	0.21

[abc] Treatment means with different superscripts are different ($P < 0.05$).

Table 2. Differences in fat-free lean mass predicted between pigs fed ractopamine and control pigs

Independent Variables and Equations	RAC16 – Control [a]		RAC-P – Control [a]		
	Difference, lb	% predicted	Difference, lb	% predicted	RSD, kg
Carcass weight, last rib midline backfat					
Schinckel et al., 2003	1.20	17.8	5.00	31.8	6.34
Schinckel et al., 2001	1.03	15.4	4.56	29.1	6.45
National Pork Board, 2000	1.06	15.8	4.59	29.2	6.41
National Pork Board, 2002	1.19	4.59	5.14	32.7	6.39
Carcass weight, tenth rib fat depth, loin muscle area					
Schinckel et al., 2003	3.34	49.7	8.49	54.1	5.49
Schinckel et al., 2001	3.13	46.5	7.74	49.3	5.67
National Pork Board, 2000	3.63	53.9	8.80	56.7	5.62
National Pork Board, 2002	3.44	51.1	7.03	44.8	5.80
NPPC, 1991	3.43	50.9	8.59	54.7	5.80
Live weight, live ultrasonic backfat and loin muscle area					
Schinckel et al., 2003	3.69	54.8	8.28	52.8	5.57
Schinckel et al., 2001	2.99	44.4	6.90	44.0	5.69
National Pork Board, 2000	2.78	41.3	7.03	44.8	5.95
National Pork Board, 2002	1.50	22.3	9.06	57.7	5.67
NPPC, 1991	2.56	38.1	5.55	41.8	5.95

[a] The actual difference in fat-free lean mass was 6.74 lbs between the CON and RAC16 pigs and 15.69 lbs between the CON and RAC-P pigs.