Total Body Electrical Conductivity as a Research Tool in Pork Carcass Evaluation

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SUMMARY

TOBEC (Total Body Electrical Conductivity) readings combined with 10th rib fat depth, warm carcass weight, primal cut weight, warm carcass length, or warm carcass temperature accurately estimates fat-free lean mass in carcasses and/or primal cuts. TOBEC can be used as a substitute for complete dissection in pork carcass composition research.

INTRODUCTION

Complete dissection or grinding of animal carcasses is routinely utilized in animal research to assess treatment effect on animal lean meat deposition. Complete dissection of carcasses is costly and time consuming.

TOBEC methodology is based on the principle that a conductive mass placed in an electromagnetic field will perturb the field. The degree of perturbation is dependent on the amount of conductive mass present. Lean tissue, with its greater electrolyte content, is a much better electrical conductor than fat and this difference is maximized at low frequencies. TOBEC has been demonstrated to be accurate in estimating body composition in pork (FORREST et al., 1988; KUEI et al., 1989; KUEI et al., 1990), human (COCHRAN et al., 1986; FIOROTTO et al., 1987; VANITALLIE et al., 1990; VAN LOAN and MAYCLIN, 1987) and small laboratory animals (CASTRO et al., 1990; WALSBERG, 1988).

Previous work in our laboratory focused on the application of TOBEC to estimate pork carcass composition in commercial slaughter operations (FORREST et al., 1988; KUEI et al., 1989; KUEI et al., 1990). Speed and accuracy were the major issues under that situation. Common carcass measurements, e.g. 10th rib fat depth and loin muscle area, are difficult to collect on fast slaughter lines. However, these measurements are reasonably easy to obtain in laboratory research. The objective was to study the feasibility of using TOBEC combined with other carcass measurements in lieu of dissection for pork carcass composition research.

MATERIALS AND METHODS

Three-hundred-twenty-five market weight pigs were slaughtered at the Purdue University Meat Science Laboratory. After eviscerating and splitting, carcass temperature (semimembranosus muscle of the ham), length (from distal end of hind foot to the most anterior point on the carcass) and carcass weight were measured. TOBEC measurements were conducted with an Agmed Inc. HA-2[a] electromagnetic scanner. The warm right side of the carcass was introduced into the electromagnetic field, hind foot first. Detailed TOBEC analyzing procedures are described by KUEI et al. (1989).

Carcass physical dissection was begun after an overnight chill at 2°C. Carcasses were ribbed between the 10th and 11th ribs, 10th rib fat depth was measured at the 3/4 point off the midline over the longissimus muscle as described in NPPC (1988). Loin muscle area was measured with a grid. Last rib backfat thickness was measured on the dorsal midline opposite

[a] Agmed Inc., Springfield IL, USA.

the last thoracic vertebra. The right carcass side was fabricated into rough ham, loin and shoulder then trimmed to wholesale primal cuts. Each trimmed primal cut was then dissected into lean, fat, skin and bone. Lipid content of dissected lean was determined by Soxhlet extraction procedures. Dissected lean was standardized to contain 0% fat (fat-free lean).

Table 1. Means and standard deviations for experimental animals.

	Estimation n=280		Validation n=45	
	Mean	SD[c]	Mean	SD[c]
Slaughter weight (kg)	108.5	11.4	109.4	10.7
Warm carcass weight (kg)	81.0	9.0	81.1	8.8
Longissimus muscle area, 10th rib (cm^2)	34.2	5.4	34.6	4.9
Fat depth, 3/4 measurement, 10th rib (cm)	2.9	.7	2.9	.8
Backfat thickness, midline, last rib (cm)	2.5	.5	2.5	.5
Warm carcass temperature (°C)	38.7	1.4	38.8	1.1
Carcass length hind foot to fore foot (cm)	151.5	8.8	150.6	8.3
Rough cut weight				
Ham (kg)[a]	9.7	1.2	9.8	1.0
Loin (kg)[a]	10.3	1.4	10.4	1.5
Shoulder (kg)[a]	8.6	1.0	8.7	1.0
Trimmed wholesale primal cut weight				
Ham (kg)[a]	9.1	1.1	9.2	.9
Loin (kg)[a]	7.2	.9	7.2	.7
Shoulder (kg)[a]	7.3	.9	7.4	.8
Fat-free lean mass				
Ham (kg)[a]	5.5	.8	5.6	.6
Loin (kg)[a]	4.5	.7	4.5	.5
Shoulder (kg)[a]	4.5	.6	4.6	.5
Carcass (kg)[b]	36.2	4.9	36.7	3.8

[a] Right side of carcass.
[b] Right side doubled.
[c] Standard deviation.

Animals were randomly divided into two groups. Prediction equations were developed on data from 280 pigs and these equations were validated on the remaining 45 pigs. Regression equations to predict fat-free lean mass in each primal cut and carcass were developed using a maximum R^2 stepwise procedure with TOBEC readings, 10th rib fat depth, loin muscle area, warm carcass weight, trimmed primal cut weight, rough cut weight, warm carcass length and warm carcass temperature serving as independent variables.

RESULTS AND DISCUSSION

Carcass traits were similar for estimation and validation samples and are representative of that found in US commercial herds (Table 1).

TOBEC reading combined with carcass length, temperature and weight accurately estimates fat-free lean mass in carcasses (R^2 = .89, RSD = 1.64) (Table 2). Fat-free lean mass in hams was also accurately estimated (R^2 = .87, RSD = .29). Warm carcass weight was not significant at P > .05 level in this equation. The accuracy of estimation of fat-free lean mass in loins and shoulders was lower.

Adding 10th rib fat depth as the fifth independent variable in the model increases R^2 by 1-3% (Table 3). The improvement was most noticeable in estimating fat-free lean mass in carcasses (R^2 = .92 and RSD = 1.40 compared with R^2 = .89 and RSD = 1.64). It is necessary to rib the carcass to measure the 10th rib fat depth. This measurement can be collected without ribbing the carcass by using optical probes. If ribbing carcasses is impossible, the alternative is to use midline backfat thickness at the last rib. However, the improvement in

Table 2. Prediction equations (four variable) for fat-free lean mass(kg) in primal cuts and carcass.

	Intercept	b-value	R^2	RSD
Carcass	17.38***		.89	1.64
A95-120[a]		.01***		
Carcass length		.11***		
Carcass temperature		-.46***		
Carcass weight		-.02		
Ham	3.50***		.87	.29
D20-45[a]		.07***		
D100-120[a]		-.02***		
Carcass temperature		-.07***		
Carcass length		.01		
Loin	1.24*		.76	.32
A0-125[a]		.001***		
Carcass length		.02***		
Carcass temperature		-.07***		
Carcass weight		.001		
Shoulder	1.46*		.82	.27
D60-90[a]		.04***		
Carcass length		.02***		
A0-35		.001***		
Carcass temperature		-.05***		

*** P < .001; * P < .05.
[a] TOBEC readings; refer to KUEI et al. (1989).

Table 3. Prediction equations (five variable) for fat-free lean mass(kg) in primal cuts and carcass with 10th rib fat depth in the equations.

	Intercept	b-value	R^2	RSD
Carcass	16.45***		.92	1.40
A90-120[a]		.01***		
Fat depth, 10th rib		-1.72***		
Carcass length		.08***		
Carcass weight		.14***		
Carcass temperature		-.35***		
Ham	3.27***		.88	.28
D20-45[a]		.07***		
Carcass length		.01***		
D100-120[a]		-.02***		
Carcass Temperature		-.06***		
Fat depth, 10th rib		-.08***		
Loin	1.18***		.79	.30
A0-125[a]		.001***		
Carcass length		.02***		
Fat depth, 10th rib		-.22***		
Carcass weight		.02***		
Carcass temperature		-.05***		
Shoulder	.90***		.85	.25
D60-90[a]		.04***		
Carcass length		.02***		
Fat depth, 10th rib		-.15***		
A0-35[a]		.002***		
Carcass temperature		-.03*		

*** P < .001; ** P < .001; * P < .05.
[a] TOBEC readings; refer to KUEI et al. (1989).

accuracy was less, compared with 10th rib fat depth measurement, with R^2 = .90, RSD = 1.55 for carcasses; R^2 = .88, RSD = .29 for hams; R^2 = .78, RSD = .31 for loins; and R^2 = .84, RSD = .26 for shoulders.

Adding primal cut weight or rough cut weight improves the accuracy of estimating fat-free lean mass in hams, loins and shoulders (Table 4). Total fat-free lean mass in carcasses is accurately estimated by a four variable equation including TOBEC reading, 10th rib fat depth, carcass length and weight in the model (R^2 = .91, RSD = 1.46). A four variable model with primal cut weight as one of the independent variables estimated fat-free lean mass in hams, loins and shoulders with R^2 = .93 and RSD = .22, R^2 = .90 and RSD = .20, and R^2 = .91 and RSD = .19, respectively.

Substitution of rough cut weight for primal cut weight in prediction equations may save labor without significantly affecting the accuracy; R^2 = .93 and RSD = .22 for hams, R^2 = .88 and RSD = .23 for loins, and R^2 = .89 and RSD = .22 for shoulders. Unless every institute trims primal cuts by the same definition, it is difficult to generate a universal equation. Fabrication into rough cuts without trimming is much easier to standardize.

The tail and an 18 cm (7 inck) skin collar were removed from the rough hams to prepare primal ham cuts. With this minor difference the accuracy and b-values were nearly the same for rough and primal ham cuts. However, there were major differences in weight and other characteristics between rough and primal loin cuts, as well as rough and primal shoulder cuts. Backfat of the rough loin cuts was trimmed to 6-7 mm to make primal loin cuts and backfat of

Table 4. Prediction equations (four variable) for fat-free lean mass (kg) in primal cuts and carcass with 10th rib fat depth in the model.

Carcass or trimmed primal cut equations

Variable	Intercept	b-value	R^2	RSD
Carcass	3.45*		.91	1.46
A95-120[a]		.01***		
Fat depth, 10th rib		-1.85***		
Carcass length		.09***		
Carcass weight		.13***		
Ham	3.23***		.93	.22
Trimmed ham weight		.40***		
Fat depth, 10th rib		-.27***		
D20-45[a]		.03***		
Carcass temperature		-.05***		
Loin	-.19		.90	.20
Trimmed loin weight		.51***		
Fat depth, 10th rib		-.19***		
A0-125[a]		.001***		
Carcass length		.01***		
Shoulder	.37*		.91	.19
Trimmed shoulder weight		.43***		
Fat depth, 10th rib		-.21***		
D60-90[a]		.02***		
Carcass length		.01***		

Rough cut equations

Variable	Intercept	b-value	R^2	RSD
Ham	3.45***		.93	.22
Rough ham weight		.36***		
D20-45[a]		.03***		
Fat depth, 10th rib		-.26***		
Carcass temperature		-.06***		
Loin	.36		.88	.23
Rough loin weight		.31***		
Fat depth, 10th rib		-.46***		
A0-125[a]		.001***		
Carcass length		.01***		
Shoulder	.49*		.89	.22
Fat depth, 10th rib		-.26***		
D60-90[a]		.03***		
Rough shoulder weight		.28***		
Carcass length		.01***		

*** $P < .001$; * $P < .05$.
[a] TOBEC readings; refer to KUEI et al. (1989).

Table 5. Test bias between estimation and validation samples for equations in table 4.

	Fat-free lean mass (kg) Bias	SD[a]	CV[b]
Carcass	-.14	1.30	3.54
Trimmed primal cut			
Ham	-.03	.20	3.55
Loin	-.04	.18	3.98
Shoulder	-.02	.19	4.17
Rough cut			
Ham	.01	.21	3.72
Loin	-.04	.22	4.87
Shoulder	-.01	.21	4.61

[a] Standard deviation.
[b] Coefficient of variation.

dorsal portion of rough shoulder cuts was also trimmed to 6-7 mm to make primal shoulder cuts. These differences not only affect the accuracy in estimating fat-free lean mass in loins and shoulders, but also significantly change the b-values.

Statistical analysis for main effects revealed that the same equation may be used for animals of different gender, weight or fat depth groups (data not shown). Addition of 10th rib loin muscle area did not significantly increase the prediction accuracy. Table 5 shows that bias was non existent in the equations presented in Table 4.

CONCLUSIONS

The precision with which fat-free lean mass in primal cuts and carcasses was measured using TOBEC, suggests that it is feasible to use TOBEC in lieu of dissection for pork carcass composition research.

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