Mechanisms for Improving the Prediction of Carcase Composition using Subcutaneous Fat Thickness

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SUMMARY:

In lightweight carcases ranging from 153 to 267 kg P8 fat thickness was an accurate predictor of the percentages of side fat and side muscle, and hot side weight plus P8 fat thickness, an accurate predictor of the weights of the two carcase components. In heavier carcases ranging from 277 to 382 kg P8 fat thickness and hot side weight were not adequate for prediction and required the addition of eye muscle area to give reasonable accuracy.

INTRODUCTION:

Since MURPHEY *et al.* (1960) demonstrated the close association between 12th rib fat thickness and cutability, subcutaneous fat thickness measurements have been used throughout the world to predict saleable beef yield. Modern marketing calls for a very accurate description of carcase composition and some authorities, like AUS-MEAT in Australia, believe that the subcutaneous fat thickness measurement does not explain enough of the variance in saleable beef yield, carcase muscle or carcase fat. This has led to the addition of characteristics such as eye muscle area and muscle score to the fat thickness measurement, often at considerable cost and often with little improvement in accuracy.

The object of this study was to attempt first to improve the prediction of the fat thickness measurement in simple regression by examining breed-carcase weight group interactions, and then to assess the value of added regressors.

MATERIALS AND METHODS:

Sixty-eight grass-fed steers (24 Hereford, 22 Brahman and 22 Brahman x Hereford) were slaughtered sequentially at approximately 300, 400, 500 and 600 kg liveweight to yield carcases of a mean hot weight of 163.9, 235.8, 293.6 and 351.0 kg respectively. Twelfth rib fat thickness (MURPHEY *et al.*, 1960), rump P8 fat thickness (MOON, 1980), visual muscle score and eye muscle area at the 10th rib were recorded on the chilled right sides which were then totally dissected into muscle, bone, fat and connective tissue. Simple regressions of percentage side fat and percentage side muscle on subcutaneous fat thickness measurements were examined for breed effects in relation to carcase weight group and adjusted fat thickness. After defining the optimum prediction regime for simple regression, the value of multiple regression was assessed by adding hot side weight, eye muscle area and muscle score to the fat thickness measurements.

RESULTS AND DISCUSSION:

Because of the close similarity in findings between 12th rib fat thickness and rump P8 fat thickness, only the latter is reported in the remainder of this paper. Mean squares and tests of significance showed that there were no significant effects from breed and weight group interactions upon the estimation of percentage side components from fat thickness, indicating no significant variations in the regression coefficients between-breed within weight group and between-weight group within breed. Least square means analyses showed that at the same rump P8 fat thickness breed differences occurred in weight groups 3 and 4 for both side fat percentage and side muscle percentage. Therefore the carcases were rearranged into two weight groups, WG1 containing the two lighter groups with a mean hot carcase weight now of 198.8 kg, and WG2 including the two heavier groups giving a mean hot carcase weight of 326.6 kg. The data were then re-analysed.

Table 1 shows that breed x weight group interactions occurred in the estimation of side fat percentage ($p<0.05$) but not in the estimation of side muscle percentage. However there were no significant breed differences among the regression coefficients of WG1 or WG2 for the prediction of side fat (Table 2).

Table 1. Mean squares and tests of significance for effects of breed and weight group (two weight groups) on the estimation of side fat percentage and side muscle percentage from rump P8 fat thickness

Source	DF	Mean squares of Side fat (%)	Mean squares of Side muscle(%)
B	2	0.611^{NS}	0.006^{NS}
WG	1	141.384**	41.255**
B x WG	2	6.799^{NS}	1.685^{NS}
P8FT	1	222.031**	67.493**
P8FT x B x WG	5	16.379*	5.307^{NS}
Error	56	5.908	4.640
Total	67		

B, Breed; WG, Weight group; P8FT, P8 fat thickness * $p<0.05$ ** $p<0.01$ NS Not significant

There were significant differences in coefficients between weight groups within breed. In each of the three breeds, the growth coefficients for side fat percentage were greater in WG1 than in WG2. A comparison of the growth coefficients within each weight group showed that breed did not explain any important differences in the regression, side fat percentage on fat thickness. In the regression of side muscle percentage on rump P8 fat thickness, a comparison of regression coefficients between breeds within weight group, and between weight groups within breed, showed that there were no significant differences. So the relationship between side muscle percentage and fat thickness was not modified by breed or weight group, or their interactive effects.

Table 2. Between-breed within weight group, and between-weight group within breed differences in regression coefficients for the estimation of side fat percentage and side muscle percentage from rump P8 fat thickness

Breed and weight group	Side fat (%) "b" difference	Side fat (%) SE	Side muscle (%) "b" difference	Side muscle (%) SE
Weight group 1				
H - B	0.025^{NS}	0.299	0.084^{NS}	0.265
H - BH	0.094^{NS}	0.336	0.059^{NS}	0.298
B - BH	0.069^{NS}	0.323	-0.025^{NS}	0.287
Weight group 2				
H - B	0.211^{NS}	0.296	-0.142^{NS}	0.262
H - BH	0.191^{NS}	0.239	-0.180^{NS}	0.212
B - BH	0.020^{NS}	0.327	-0.038^{NS}	0.289
Hereford				
WG1 - WG2	0.539*	0.260	-0.198^{NS}	0.231
Brahman				
WG1 - WG2	0.725*	0.330	-0.424^{NS}	0.293
Brahman x Hereford				
WG1 - WG2	0.636*	0.320	-0.437^{NS}	0.283

H, Hereford; B, Brahman; BH, Brahman x Hereford; WG1,WG2: Weight groups 1 and 2

* $p<0.05$ NS Not significant

Table 3. Regressors which, when added to rump P8 fat thickness, improved the prediction of carcase fat and carcase muscle †

Dependent variable	a	P8FT	HSW	EMA	MS	RSD (% or kg)	R^2
Weight group 1 (153 - 267 kg)							
Fat (%)							
	11.739**	0.850**				1.83	0.73
Fat (kg)							
	7.590**	1.467**				2.25	0.84
	-2.548^{NS}	0.920**	0.130**			1.60	0.92
	1.512^{NS}	1.360**		0.114**		1.99	0.88
	6.111**	1.319**			0.991*	2.15	0.86
Muscle (%)							
	67.277**	-0.456**				1.70	0.47
Muscle (kg)							
	48.510**	2.117**				8.28	0.44
	-1.872^{NS}	-0.603**	0.645**			2.08	0.97
	39.782**	1.244**			5.845**	7.05	0.61
	15.045**	1.054**		0.520**	3.827**	5.17	0.80
Weight group 2 (277 - 382 kg)							
Fat %							
	18.574**	0.374**				3.46	0.18
	29.973**	0.381**		-0.150*		3.28	0.29
	23.438**	0.269*	0.106**	-0.273**		2.96	0.44
Fat (kg)							
	24.766**	0.812**				6.75	0.22
	-14.729^{NS}	0.518*	0.265**			5.11	0.57
	-1.145^{NS}	0.417*	0.372**	-0.390**		4.40	0.69
Muscle (%)							
	63.823**	-0.222*				2.65	0.12
	54.538**	-0.228*		0.123*		2.48	0.25
	59.228**	-0.147^{NS}	-0.076**	0.210**		2.27	0.39
Muscle (kg)							
	7.453^{NS}	-0.395*	0.546**			4.28	0.83
	24.759^{NS}	0.172^{NS}		0.845**		7.52	0.48
	-3.544^{NS}	-0.313^{NS}	0.459**	0.316**		3.73	0.88

† All regressions are significant * $p < 0.05$ ** $p < 0.01$ NS Not significant

a, Intercept; P8FT, Rump P8 fat thickness; HSW, Hot side weight; EMA, Eye muscle area; MS, Muscle score

Because the regression coefficients for side fat percentage differed between weight groups, general regression (breed and weight group ignored), if used, would require more than simple linear regression to explain the relationship. Least square means analysis showed that at the same rump P8 fat thickness there were significant differences in WG2 for side fat percentage estimation but not in WG1. In the heavier weight group Brahman x Hereford steers had less fat than Herefords (p<0.05) and Brahmans (p<0.01). At the adjusted fat thickness there were no breed differences in WG1 or WG2 for the estimation of side muscle percentage. Therefore rump P8 fat thickness would seem to be an adequate predictor of carcase composition in lighter carcases (WG1) but not in the heavier carcase group (WG2). This finding was re-enforced by an examination of correlation coefficients. Quadratic analysis applied to WG1 and to WG2 did not improve the accuracy of simple linear prediction of side fat percentage and side muscle percentage.

Table 3 shows the results of multiple regression, where additional regressors were used with P8 fat thickness, within weight group. In WG1 the best predictor of side fat percentage and side muscle percentage was P8 fat thickness alone. The addition of hot side weight, eye muscle area and muscle score, individually or in various combinations, did not contribute significantly to reducing the RSD. In predicting side fat weight, P8 fat thickness alone was a highly significant predictor. The addition of either eye muscle area or muscle score, or both, to P8 fat thickness reduced the RSD significantly but only slightly. When hot side weight was added to fat thickness the reduction in the prediction error was both significant and relatively large (2.25 kg to 1.60 kg), this combination of predictors explaining 92% of the variance in regression. The addition of eye muscle area or muscle score, or both, to P8 fat thickness and hot side weight did not improve prediction.

The findings for the prediction of side muscle weight were very similar. P8 fat thickness alone predicted side muscle weight significantly ($p<0.01$) but the RSD was high (8.28kg) with only 44% of variance explained. The addition of eye muscle area or muscle score, or both, to P8 fat thickness reduced the RSD substantially, but nowhere near the large reduction resulting from the addition of hot side weight to the fat thickness measurement (RSD 2.08kg). The addition of eye muscle area or muscle score to P8 fat thickness and hot side weight did not improve the error of prediction of this last-mentioned combination.

Therefore in the lighter weight group of carcases the best prediction of side fat percentage and side muscle percentage was P8 fat thickness alone, and the best prediction of the weights of these two components was given by P8 fat thickness together with hot side weight.

In WG2, regressions of side fat percentage and side muscle percentage on P8 fat thickness were significant but the RSD's were relatively high (3.46% and 2.65% respectively) with only 18% and 12% respectively, of the variance explained. The addition of hot side weight or muscle score, or both, to P8 fat thickness did not give improved accuracy of prediction for either fat or muscle percentage, but the combination of P8 fat thickness, hot side weight and eye muscle area did significantly improve the percentage prediction of each carcase component. Even so, the RSD's were still relatively high (2.96% for fat, and 2.27% for muscle) and the variance explained was still not great (44% and 39% respectively). Muscle score did not contribute significantly to prediction in any combination.

For the predictions of side fat weight and side muscle weight in WG2, the addition of hot side weight to P8 fat thickness resulted in far greater accuracy than for P8 fat thickness alone, but the most accurate prediction in each case was given by a combination of fat thickness, hot side weight and eye muscle area. Muscle score, in any combination, did not improve the accuracy of prediction.

So in the heavier carcase group, P8 fat thickness alone is not an accurate predictor of side fat or side muscle (percentage or weight) and requires the addition of eye muscle area together with hot side weight to predict with reasonable accuracy.

<u>CONCLUSIONS</u>: In Australia where "local" and "export" carcases are clearly different in weight and are similar to the two weight groups studied here, different objective classification methods are necessary to adequately quantify the different types of carcases.

<u>REFERENCES</u>: MOON, J.B. (1980). An Investigation of Alternative Sites for Measuring Fat Depth in Beef Carcases. Thesis. Slaughtering and Meat Inspection Branch, Queensland Department of Primary Industries, Brisbane, Australia.

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