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The Estimation of Beef Carcass Muscle Using Cross-sectional Area of *M. longissimus dorsi* at the Fifth Rib

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ABSTRACT

The improvements in the accuracy of prediction of side muscle (weight and proportion) using measurements of eye muscle area at the 10th rib (EMA_{10}) *and eye muscle area at the 5th rib* (EMA_5), *were compared in* 48 *steers, grain-fed for the Japanese market.*

For side muscle proportion the addition of EMA_{10} *to hot side weight and a fat thickness measurement did not improve prediction but the addition of* EMA_5 *did.* P8 *fat thickness together with hot side weight and* EMA_5 *(each,* $P < 0.001$*) predicted side muscle proportion with an SEE of 2·05% and an* R^2 *of* 61%, *while the values for 10th rib thickness together with hot side weight and* EMA_5 *(each,* $P < 0.001$*) were* 2·09% *and* 68%, *respectively.*

For the prediction of side muscle weight a fat thickness measurement and hot side weight (both, $P < 0.001$*) explained* 77–84% *of variance; the addition of an eye muscle area measurement further improved prediction with the most accurate being* P8 *fat thickness together with hot side weight and* EMA_5.

INTRODUCTION

Most scientific studies on the contribution of eye muscle area to the estimation of muscle in beef carcasses have been conducted on *m. longissimus thoracis et lumbormum* (*m. longissimus*) at the 10th or 12th ribs (Cole *et al.*, 1960; Murphey *et al.*, 1960; Crouse *et al.*, 1965; Brackelsberg and Willham, 1968; Johnson *et al.*, 1992). Following the recent development of B-mode ultrasound technology, its application to the measurement of eye muscle area in both live cattle and carcasses has been directed at *m. longissimus* from the 10th rib to the 4th lumbar vertebra (Davis *et al.*, 1964; Gillis *et al.*, 1973; Simm, 1983; Porter *et al.*, 1990).

Because of commercial convenience many of the qualitative and quantitative values of carcasses have been traditionally assessed on *m. longissimus* over the caudal ribs area (Hedrick *et al.*, 1965; Stouffer, 1966). In the Chiller Assessment Scheme used on heavy export carcasses, AUS-MEAT recommends measuring cross-sectional area of *m. longissimus* at the 10th rib (Anon., 1991). While eye muscle area is most conveniently measured on this muscle over the last few ribs, it may not be the most accurate site. *M. longissimus*, the longest muscle in the carcass, originates on the sacrum and terminates at the seventh cervical vertebra, undergoing a marked change in cross-sectional shape at the sixth thoracic vertebra (Butterfield and May, 1966). Two features may make the cross-sectional area of *m. longissimus* difficult to measure accurately over the caudal ribs area. One is the strong primary tendon of origin passing obliquely across the dorsum of the muscle and sometimes indenting this surface. The other is the relationship of *m. longissimus* to *m. spinalis* and *m. multifidis* which sometimes results in the medial border of *m. longissimus* being poorly defined.

The following study was undertaken to compare the value of eye muscle area measured at the 10th rib with eye muscle area measured at the 5th rib in predicting the weight and percentage of carcass muscle.

MATERIALS AND METHODS

Twelve steers from each of four genotypes were grain-fed to meet Japanese market specifications. After the cattle were slaughtered and their carcasses chilled, a number of measurements were made. These included subcutaneous fat thickness at the rump (P8), 12th rib (FT_{12}), 10th rib (FT_{10}) and 5th rib (FT_5) using a stainless steel ruler; eye muscle area was measured at the 10th rib (EMA_{10}) and the

TABLE 1
Details* of Four Genotypes of Steer Carcasses Used to Study Muscling

Genotype	*Days on grain*	*Hot side weight*† *(kg)*	*P8 fat thickness (mm)*	*12th rib fat thickness (mm)*	*Composition (% of hot side weight)*	
					Muscle	*Fat*
Angus	162	202	18·1	20·3	50·2	34·3
	(120–186)	(176–237)	(5–28)	(13–28)	(43·6–54·4)	(26·5–44·0)
Hereford	172	209	20·4	18·9	51·5	33·3
	(120–200)	(159–256)	(15–28)	(12–28)	(48·2–57·3)	(27·0–37·4)
Murray Grey	128	180	18·3	16·8	52·6	31·7
	(106–169)	(146–202)	(10–27)	(12–25)	(44·2–58·0)	(26·0–36·9)
Santa Gertrudis	174	188	14·7	13·9	54·1	29·5
	(120–204)	(168–214)	(9–21)	(8–19)	(47·9–57·4)	(22·2–36·2)

*Mean values with ranges shown in parenthesis.
†'Standard' carcass defined by AUS-MEAT (Anon., 1987).

5th rib (EMA_5), using a transparent grid divided into 1 cm^2 units; and hot side weight (HSW) was recorded. The measurement techniques were described by AUS-MEAT (Anon., 1991). Details of the carcasses are given in Table 1.

Simple and multiple regression analyses were carried out to determine the value of single measurements or combinations of measurements in predicting the percentage and the weight of total side muscle. These two dependent variables were regressed on each fat thickness measurement to which each of the eye muscle area measurements and hot side weight were progressively added.

RESULTS

Figure 1 shows features of *m. longissimus* at the 5–6th ribs where the rib set is removed from the chuck roll, and at the 10–11th ribs where the rib set is removed from the loin. At the 5th rib position eye muscle area is about half that at the 10th rib and it is regular in outline and latero-medially flattened. Its border is usually clearly delineated at this level, whereas, at the 10th rib, the border is often difficult to distinguish from *M. multifidus dorsi* and *M. spinalis dorsi.*

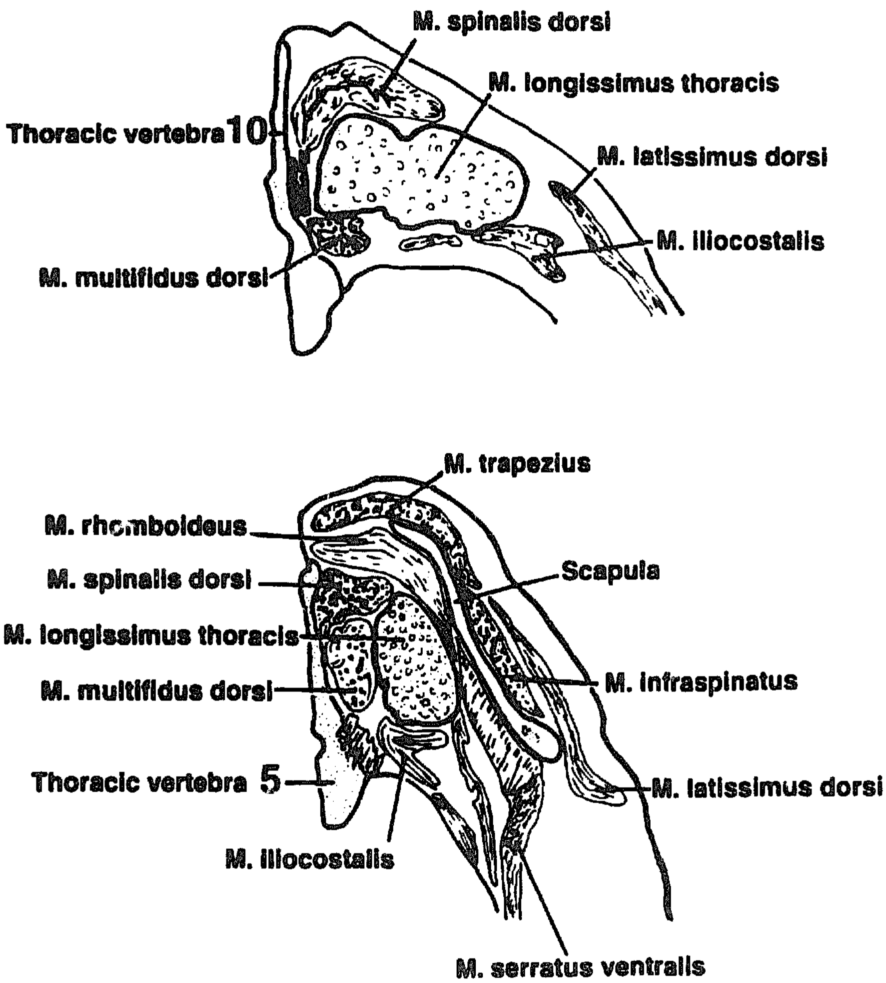

Fig. 1. Cross-section of the spinal muscles of the beef side at the 10th and 5th ribs.

In Table 2 those measurements which contributed significantly ($P<0{\cdot}05$ or greater) to the prediction of percentage side muscle are shown. From this table, it may be noted that, with respect to the prediction of percentage side muscle:

- FT_5 was a poor contributor. As a single regressor it was a significant predictor ($P<0{\cdot}05$) of percentage side muscle weight but the standard error of estimate (SEE) was very large (3·42%) and only 15% of variance was explained. In multiple regression it did not help prediction.
- HSW, when added to each fat thickness measurement, did not improve prediction.
- Both EMA_5 and EMA_{10}, when added individually to each of the three fat thickness measurements P8, FT_{12} and FT_{10}, resulted in a significantly improved prediction of percentage side muscle weight, in all cases except for FT_{10} + EMA_{10}. All five regressions were of about equal accuracy and explained approximately the same degree of variance (42–50%).
- When EMA_5 + HSW and EMA_{10} + HSW were added to the three fat thickness measurements to predict percentage side muscle weight a very different result was obtained for each of the two eye muscle area sites. EMA_{10} did not cause any significant improvement in the accuracy of prediction but EMA_5 did. In the latter case, with P8, all three regressors contributed significantly ($P<0{\cdot}001$) in reducing the SEE (2·05%), with 61% of variance accounted for; with FT_{10} all three regressors again contributed significantly ($P<0{\cdot}001$) in reducing the SEE (2·09%) with 68% of variance explained. Those two combinations of regressors, both involving EMA_5, were clearly the best used in the prediction of percentage side muscle.

When EMA_5 and EMA_{10} were used alone to predict percentage side muscle, neither simple regression was significant. When each of these measurements was

TABLE 2
Prediction of Side Muscle Weight Expressed as a Percentage of Hot Side Weight

Regressors[†]	*Coefficient of determination* (R^2)	*Standard error of estimate at mean* (%)
P8***	0·41	2·52
FT_{12}***	0·38	2·60
FT_5*	0·15	3·42
FT_{10}***	0·43	2·80
P8*** + EMA_5**	0·50	2·34
FT_{12}*** + EMA_5*	0·42	2·52
FT_{10}*** + EMA_5*	0·49	2·64
P8*** + EMA_{10}*	0·46	2·43
FT_{12}*** + EMA_{10}**	0·47	2·39
P8*** + HSW*** + EMA_5***	0·61	2·05
FT_{12}*** + HSW* + EMA_5**	0·48	2·38
FT_{10}*** + HSW*** + EMA_5***	0·68	2·09
EMA_5*** + HSW***	0·24	2·87
EMA_{10}*** + HSW***	0·24	2·88

*$P<0{\cdot}05$; **$P<0{\cdot}01$; ***$P<0{\cdot}001$.
[†]Abbreviations explained in Materials and Methods.

TABLE 3
Prediction of Side Muscle Weight

Regressors[†]	*Coefficient of determination* (R^2)	*Standard error of estimate at mean* (g)
P8*** + HSW***	0·84	4806
FT_{12}*** + HSW***	0·83	4961
FT_{10}*** + HSW***	0·77	5302
P8* + EMA_5***	0·64	7169
FT_{10}* + EMA_{10}***	0·40	8602
P8*** + HSW*** + EMA_5***	0·89	3962
FT_{12}*** + HSW*** + EMA_5**	0·85	4558
FT_{10}*** + HSW*** + EMA_5***	0·87	4006
P8*** + HSW*** + EMA_{10}*	0·86	4516
FT_{12}*** + HSW*** + EMA_{10}***	0·86	4424
FT_{10}* + HSW*** + EMA_{10}*	0·80	5006
EMA_5***	0·61	7489
EMA_{10}***	0·32	9799
EMA_5*** + HSW**	0·78	5530
EMA_{10}*** + HSW**	0·79	5479

*$P<0.05$; **$P<0.01$; ***$P<0.001$.
[†]Abbreviations explained in Materials and Methods.

combined with HSW there was a significant improvement in prediction ($P<0.001$) but only 24% of variance was explained in each case and the standard errors of estimate were relatively high.

For the prediction of side muscle weight the regressors that contributed significantly are shown in Table 3.

This table shows that:

— All fat thickness measurements except FT_5, when combined with HSW, contributed significantly to regression ($P<0.001$) and were relatively accurate predictors, explaining 77–84% of variance.

— Regressions based on P8 + EMA_5 and FT_{10} + EMA_{10} were significant predictors of side muscle weight, but in each case the SEE was much higher than for the fat thickness measurements combined with HSW.

— The most accurate predictions were obtained by adding eye muscle area (EMA_5 or EMA_{10}) and HSW to the fat thickness measurements. In this respect EMA_5 + HSW was clearly superior, particularly when added to P8 or FT_{10}. Here the standard errors of estimate and variance explained were 3962 g and 89% respectively for P8, and 4006 g and 87% for FT_{10}.

— Whilst the prediction of side muscle weight from EMA_5 or EMA_{10}, alone or combined with HSW, resulted in significant regressions, the SEE, in all cases, was higher than for combinations of fat thickness and HSW.

DISCUSSION

Eye muscle area measurements alone or combined with HSW were not useful predictors of percentage or weight of side muscle because of relatively high prediction errors. While eye muscle area plus fat thickness predicted percentage side muscle with relatively low prediction errors the combinations of fat thickness, HSW and eye muscle area were the most accurate predictors of percentage and weight of side muscle. Of the two cross-sectional area measurements, EMA_5, generally about half the area of EMA_{10}, was clearly superior. This was especially evident in its combinations with P8 and FT_{10} where it was much more accurate than EMA_{10}, in predicting both percentage and weight of side muscle.

In carcass dissection studies EMA_5 may give a superior result to EMA_{10} when used to predict muscle content because of the confidence and accuracy with which an observer can measure the area of *m. longissimus* at the 5th–6th rib. At this level the cross-sectional area of the muscle is clearly defined by a smooth, regular, oval-shaped muscle capsule, even though Davis *et al.* (1964), using ultrasound measurement in live cattle, found a 'complex muscle structure' in this area (Fig. 1). At the 10th–11th rib, the outline of *m. longissimus* is often difficult to distinguish from other closely related muscles, especially *m. multifidus dorsi* and *m. spinalis dorsi.*

EMA_5 is potentially useful in two different situations. In carcass research there seems to be little reason why EMA_5 cannot be used since the measurement can be made whether using the total anatomical dissection technique or the commercial cuts technique. Its use in the commercial carcass depends on accessibility. With current trading practices, quartering at the 10th or 12th ribs facilitates the measurement of eye muscle area at this level. However, for many markets the rib set is removed from the chuck at the 5th–6th ribs so EMA_5 is available in these cases during breakdown into primal cuts. Japan, a major outlet for Australian beef, requires the rib set to be divided from the chuck at the 6th–7th ribs, so the advantages noted for EMA_5 may apply also at the 6th rib.

While current attempts to improve the accuracy of prediction of carcass composition using real-time ultrasound and velocity-of-sound are very promising (Miles *et al.*, 1987, 1990; Porter *et al.*, 1990) the practibility of the various prediction techniques available must also receive consideration. Real-time ultrasound and velocity-of-sound techniques require relatively expensive equipment that may not be appropriate for all carcass processing works. There is a need for research to be directed also at the better utilization of measurements currently in use. Johnson and Priyanto (1991) showed that a regrouping of carcass weight ranges or fat thickness ranges could be used to improve the prediction of beef carcass composition. The findings in the current study show that eye muscle area measurements may also be better utilized in prediction.

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