New Zealand Society of Animal Production online archive

Ultrasound measurements predict estimated adipose and muscle weights better than carcass measurements

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ABSTRACT

Seventy-six 6 month old Coopworth ram lambs were scanned with ultrasound for muscle depth B, fat depth C and tissue depth GR. Lambs were slaughtered, then B, C and GR measured directly on each carcass. The hindquarters (loin and hind legs) of each carcass were boned out and soft tissue minced then analysed for lipid and protein content. From these, hindquarter adipose and muscle weights were estimated.

Correlations of estimated tissue weights with ultrasound measurements were consistently higher than those with direct measurements (averaging 0.423 versus 0.293, respectively). The latter method may be more prone to measurement errors associated with displacement, damage or distortion of tissues or positioning of the measurement site. It is concluded that ultrasound measurements may be better than those made directly on the carcass for predicting tissue weights.

Keywords: ultrasound; fat; muscle; linear dimensions; carcass composition; sheep; prediction; correlation.

INTRODUCTION

Carcass composition is an important trait in the meat industry, where it influences carcass value, and in sheep breeding where the aim is to improve lean tissue growth (Simm, Young & Beatson, 1987). In the New Zealand meat industry, carcass fatness is assessed with reference to GR, a tissue depth that is largely fat, over the 12th rib (Kirton, 1989). In practice fatness grades are assigned to carcasses on the basis of visually assessed fatness with marginal cases being determined by direct measurement of GR. Modern selection criteria to improve lean tissue growth generally use aggregate breeding values with selection indices incorporating carcass linear dimensions measured by ultrasound (eg. Simm *et al.*, 1987).

Reports of the relationship between carcass tissue depths and carcass tissue weights have been made (eg. Kirton & Johnson, 1979; Nicol & Parratt, 1984) but none have compared directly the accuracy with which tissue weights are predicted by ultrasound in comparison to direct carcass measurement.

Data were available from a larger study (Deaker, Young, Fraser & Rowarth, 1994) permitting examination of the relative accuracy with which tissue depths, measured by ultrasound or directly on the carcass, can predict tissue weights.

MATERIALS AND METHODS

Seventy-six 6 month old Coopworth ram lambs were scanned with ultrasound for muscle depth B, fat depth C and tissue depth GR. B is the depth of *M. longissimus* dorsi over the last rib as described by Palsson (1939). C was not measured directly over B as described by Palsson, the measurement being made over the lateral edge of this muscle. GR was scanned approximately 11cm lateral to the midline over the last rib, at a similar anatomical position in each sheep, by an experienced ultrasound operator.

Lambs were slaughtered 24h after scanning. B, C and GR were measured directly on each side of the chilled (24h) carcass. GR was measured to the nearest millimetre on the whole carcass using a standard industry probe. B and C were measured on the cut surface of the carcass cross-section after sectioning along the cranial edge of the last rib. The hindquarters (loin and hind legs) of each carcass were boned out and soft tissue minced. Two subsamples (c.100g each) of thoroughly mixed mince were taken for chemical analysis to determine lipid and crude protein content by standard techniques (see Deaker *et al.*, 1994).

Weight of bone in the carcass subsection was obtained directly. Weight of dissectible fat (adipose) was estimated using the prediction equation of Callow (1948) relating carcass adipose percentage, X, to the chemical fat (lipid) percentage of carcass soft tissue, Y ($Y = 1.071*X - 4.4$; $r = 0.99$). Muscle weight was obtained by difference. Full dissections of the whole carcass into bone, muscle and fat were not undertaken due to cost.

RESULTS

Basic statistics for the data used in this study are presented in Table 1 to characterise the animals. Correlations between estimated tissue weights and carcass linear dimensions measured either with ultrasound or directly on the carcass are detailed in Table 2. Additionally, the residual standard deviation for estimated tissue weight using tissue depth as a predictor is presented.

Overall the muscle linear dimension, B, predicted muscle weight better than fat (adipose) linear dimensions, while fat linear dimensions predicted adipose weight better than muscle linear dimensions. GR was a better predictor of adipose weight than C, perhaps reflecting absolute measurement errors having relatively more effect on the smaller fat dimension. Bone weight was the least well predicted tissue weight, which is to be expected as the predictors were measurements on fat and muscle.

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TABLE 1: Means and standard deviations (s) for live weight, hot carcass weight, tissue linear dimensions (ultrasound or direct carcass measurements) and tissue weights. All weights in kilograms and linear dimensions in millimetres.

Variable	mean	s
General		
live weight	37.4	3.7
carcass weight	17.7	2.2
Ultrasound		
B	24.2	1.8
C	3.76	0.92
GR	11.2	2.2
Direct carcass[1]		
B	26.2	2.6
C	3.6	1.4
GR	9.1	2.5
Tissue weights[2]		
adipose[3]	1.96	0.480
muscle[3]	4.48	0.763
bone	1.48	0.137

[1]means of measurements made on left and right sides of the carcass
[2]for loin+leg carcass sub-section
[3]estimated from chemical composition of soft tissue

TABLE 2: Correlations (r) between tissue weights and tissue linear dimensions (ultrasound or direct carcass measurements) together with residual standard deviations for tissue weights where linear dimension was used as a predictor. Linear dimensions were obtained from the left side of the carcass. A statistical test for the hypothesis that r=0.0 is presented.

		tissue weight[1]				
	adipose[2]		muscle[2]		bone	
tissue depth	ultrasound	carcass	ultrasound	carcass	ultrasound	carcass
r	0.48	0.28	0.32	0.26	0.52	0.29
B	***	**	**	**	***	**
rsd	0.421	0.461	0.723	0.737	0.117	0.132
r	0.58	0.44	0.22	0.03	0.36	0.17
C	***	**	*	NS	**	*
rsd	0.391	0.431	0.744	0.763	0.128	0.136
r	0.67	0.67	0.26	0.18	0.40	0.32
GR	***	***	**	*	**	**
rsd	0.356	0.356	0.737	0.751	0.126	0.130

[1]for hindquarters of carcass
[2]estimated from chemical composition of soft tissue

There is a consistent trend for ultrasound linear dimensions to predict tissue weights better than those made directly on the carcass (Table 2). The one exception is for GR as a predictor of adipose weight where there was no difference between the two.

DISCUSSION

It is assumed that hindquarter composition is closely related to whole carcass composition. While genetic differences in tissue distribution exist (Deaker & Young, 1992), such effects would act to reduce the correlations of tissue weights with both ultrasound and direct carcass measurements. Similarly, estimation of tissue weights for adipose and muscle introduces error but it would affect ultrasound and direct measurement predictions in the same way.

There was no reason to believe that significant errors resulting from operator inexperience contributed to the difference between ultrasound and direct measurements. The operator of the ultrasound equipment was very experienced at measuring B, C and GR, while the operator making direct measurements on the carcasses was an experienced research technician familiar with this procedure.

It could be argued that since the whole carcass was sectioned to obtain linear dimensions directly, the average of the left and right side measurements should be used. For the comparisons presented here it was decided that a single direct measurement should be compared with a single ultrasound measurement, each made on the left side of the carcass. However, after finding that direct measurements were not as good as ultrasound measurements, analyses were performed using mean values (of the left and right carcass measurements). These data are not presented here as they had negligible effect on the results, increasing the correlation in only five of nine cases and then with only minor changes in magnitude. Correlations between left and right measurements of B, C and GR made directly on the carcass, were 0.83, 0.86 and 0.92, respectively. However, it should be noted that these two measurements are not independent as they were measured sequentially and the possibility of unintentional operator bias cannot be discounted.

No other data were available to allow further investigation of the reasons for ultrasound measurements providing a more accurate prediction of estimated tissue weights. However, there are several causes of measurement error that may influence direct measurements to a greater degree. Specifically;

1. *tissue displacement during measurement* - pressure on the surface of the carcass (or skin in the live animal) can compress tissue to varying degrees. If carcass temperature varies (different degrees of cooling) adipose would be easier to displace in a warm carcass. Ultrasound operators have the advantage that they can look at the tissues they are studying and, to a certain extent, can adjust for such effects.
2. *tissue damage at slaughter* - when animals are skinned, some subcutaneous fat can be removed with the skin.
3. *tissue distortion prior to measurement* - sectioning of the carcass to reveal the cross-section of *M. longissimus dorsi* removes some of the support from surrounding tissues and, in our experience, can either compress or stretch out tissue, superficial layers in particular. This can have pronounced effects on measurements such as C.
4. positioning of the measurement site - once a carcass is cut in cross-section, adjustments for the position of the plane of the cut can not be made. In contrast, the ultrasound operator can adjust the position and orientation of the scan to get the correct anatomical location.
5. anatomical location - measurement C is a small fat depth directly over the muscle (Palsson, 1939). Small depths have proportionately greater errors of measurement. In practice it can be extremely difficult to obtain discrimination between animals for this fat depth in lean sheep, hence the alternative location used by the ultrasound operator in the present study.

The finding of the present study that ultrasound measurements were better than direct measurements requires verification. If true, it has important consequences in sheep breeding. Published work on the derivation of selection indices for lean tissue growth (eg. Simm *et al.*, 1987; Clarke, Waldron & Rae, 1991) has relied on data derived from dissection of large numbers of animals. Few of these studies reported measurements by ultrasound. Given the present economic climate for research it is unlikely that the opportunity to collect dissection data together with ultrasound data from large populations will arise in the foreseeable future. It may be that correlations between tissue weights and linear dimensions obtained directly on the carcass, underestimate the degree to which ultrasound tissue dimensions are related to carcass tissue weights. As a consequence, sub-optimal selection strategies could be adopted (Sheridan, 1988) or predictions of response could be underestimated.

CONCLUSIONS

Measurements of carcass tissue depths *in vivo* by experienced ultrasound operators may be more closely related to carcass tissue weights than similar measurements made directly on the carcass post-slaughter.

Previous predictions for response to genetic improvement of lean tissue growth may underestimate possible rates of response.

ACKNOWLEDGEMENTS

We thank; Mr CM Logan for ultrasound measurement; Mr MC Smith for carcass measurements; Mr P Isherwood for chemical analyses; Dr AH Kirton for critical comment on a draft manuscript.

REFERENCES

Callow, E.H. 1948. Comparative studies of meat. II. The changes in the carcass during growth and fattening, and their relationship to the chemical composition of the fatty and muscular tissues. *Journal of agricultural science, Cambridge* **38:** 174-199.

Clarke, J.N.; Waldron, D.F.; Rae, A.L. 1991. Selection objectives and criteria for terminal lamb sires. *Proceedings of the Australian association for animal breeding and genetics* **9:** 265-271.

Deaker, J.M.; Young, M.J. 1992. Subcutaneous fat distribution as assessed by ultrasound in Border Leicester and Dorset Down ewe hoggets. *Proceedings of the New Zealand society of animal production* **52:** 45-47.

Deaker, J.M.; Young, M.J.; Fraser, T.; Rowarth, J.S. 1994. Carcass, liver and kidney characteristics of lambs grazing plantain (*Plantago lanceolata*), chicory (*Cichorium intybus*), white clover (*Trifolium repens*) or perennial ryegrass (*Lolium perenne*). *Proceedings of the New Zealand society of animal production* **54:** (this volume)

Kirton, A.H. 1989. Current methods of on-line carcass evaluation. *Journal of animal science* **67:** 2155-2163.

Kirton. A.H.; Johnson, D.L. 1979. Interrelationships between GR and other lamb carcass fatness measurements. *Proceedings of the New Zealand society of animal production* **39:** 194-201.

Nicol, A.M.; Parratt, A.C. 1984. Methods of ranking two-tooth rams for fat-free carcass growth rate. *Proceedings of the New Zealand society of animal production* **44:** 253-256.

Palsson, H. 1939. Meat qualities in sheep with special reference to Scottish breeds and crosses. *Journal of agricultural science, Cambridge* **29:** 544-626.

Sheridan, A.K. 1988. Agreement between estimated and realised genetic parameters. *Animal breeding abstracts* **56:** 877-899.

Simm, G.; Young, M.J.; Beatson, P.R. 1987. An economic selection index for lean meat production in New Zealand sheep. *Animal production* **45:** 465-475.