Dual x-ray absorptiometry accurately predicts carcass composition from live sheep and chemical composition of live and dead sheep

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Abstract

This study investigated the potential for dual x-ray absorptiometry (DXA) to predict the carcass composition of a live sheep. Carcass DXA composition can be moderately well predicted from live animal DXA. DXA carcass lean was moderately well predicted from DXA live lean (r^2 of 0.73) and the regression improved with the inclusion of bodyweight (r^2 of 0.82). DXA carcass fat was well predicted from the comparison with DXA live fat (r^2 of 0.86). DXA carcass bone was well predicted from DXA live bone (r^2 of 0.93). The DXA is able to accurately predict the chemical protein, fat and total composition from both carcasses and live animals with high accuracy. The future for the DXA will exist in the determination of body composition in live animals and carcasses in research experiments but there is potential for the DXA to be used as an on-line carcass grading system in the abattoir.

Introduction

Dual-energy x-ray absorptiometry (DXA) can measure body composition and relate the proportion of muscle, fat and bone of a scanned live or dead animal (Lukaski et al. 1999). More recently, DXA scanners have been used to assess the composition of lamb carcasses and primals (Dunshea *et al.* 2007; Mercier *et al.* 2006). Studies conducted with lamb carcasses have shown that the DXA can significantly predict half or whole carcass composition. These studies have demonstrated that DXA could accurately and non-destructively predict total weight and the amount of lean and fat in sheep carcasses and also in primal cuts. Studies in pigs have shown that DXA can also accurately predict the amount of bone, fat and lean tissue in the live animal (Suster et al. 2003).

This study evaluated the potential for the DXA to predict carcass composition from a live animal DXA scan. In addition the potential for the DXA predicted lean fat and bone content of both whole lamb carcasses and live sheep were compared to chemical analysis determined protein, fat and ash.

Materials and methods

Fifty merino wethers were lot fed for 42 d and scanned using a dual x-ray absorptiometry (DXA: Norland XR-26 Fan Beam) as both a live animal (liveweight range from 44 to 81 kg, average of 58.6 kg) and whole carcass (carcass weight range from 15 to 32 kg, average of 22.9 kg). The live sheep and carcasses were positioned on the DXA table in sternal recumbency with forelimbs flexed and extended caudally, and the hindquarters flexed and level with body. The DXA produced measures of total tissue, lean, fat and bone content. The carcasses were frozen after scanning and the carcass components (including all trim) were minced (frozen to minimise moisture loss) using a commercial mincer. Chemical analysis for dry matter, ash, protein and fat was conducted. Comparisons between live animal and carcase DXA tissue weights and the chemically determined tissue weights were all undertaken using a general linear regression model (Genstat v9.0, Oxford). The prediction accuracy of the models generated was expressed with an r^2, residual standard deviation (RSD) and F values. For further experimental details see Pearce et al. (2008).

Results and discussion

Carcass DXA composition can be predicted from live animal DXA (Table 1). DXA carcass lean (CL) was moderately well predicted from DXA live lean (LL) (r^2 of 0.73) and the prediction improved with the inclusion of bodyweight (BWT) (r^2 of 0.82). DXA carcass fat (CF) was well predicted from the comparison by DXA live fat (LF) (r^2 of 0.86) and not improved with the inclusion of bodyweight to regression (r^2 of 0.86). DXA carcass bone (CB) was well predicted from DXA live bone (LB) (r^2 of 0.93). DXA carcass total weight (CT) was well predicted from DXA live total weight (LT) (r^2 of 0.86). The definition of the carcass composition of a live animal is essential for research into compositional changes due to nutrition, physiological status and genetic selection.

Table 1. Models for the prediction of dual energy X-ray absorptiometry (DXA) determined carcass lean, fat and bone mass from DXA measurements on the live animal for lean, fat and bone mass

Predictors	Best prediction model (values in parentheses are standard errors)	r^2	RSD	F value	Regression Significance
DXA Carcass Lean (CL)					
1	3.13(±1.1)+0.30(±0.028)*LL	0.73	1.1	118.1	**
2	0.47(±1.1)+0.12(±0.04)*LL+0.17(±0.03)*BWT	0.82	0.87	97.2	**
3	2.1(±1.13)+ 0.30(±0.03)*LL+0.2(±0.06)*LF	0.78	1.02	76.2	**
4	0.55(±1.2)+ 0.2090(±0.05)LL+0.0874(±0.07)LF+0.102(±0.04)BWT	0.81	0.95	56.8	**
DXA Carcass Fat (CF)					
1	2.49(±0.18)+0.52(±0.03)*LF	0.86	0.54	258.1	**
2	-0.068(±0.62) +0.41(±0.035)*LF+0.052(±0.01)*BWT	0.86	0.51	134.1	**
DXA Carcass Bone (CB)					
1	0.099(±0.03)+0.82(±0.03)*LB	0.93	0.04	384.9	**
2	0.02(±0.05)+0.71(±0.05)*LB+0.004(±0.001)*BWT	0.94	0.04	360.2	**
DXA Carcass Total (CT)					
1	1.63(±1.22)+0.43(±0.02)*LT	0.86	1.25	283.8	**

**= $P < 0.001$, BWT= Body weight at scanning, LF= DXA determined live fat, LL= DXA determined live lean, CF= DXA determined carcass fat, CL= DXA determined carcass lean, LB= DXA determined live bone, CB= DXA determined carcass bone, LT= DXA determined live total, CT= DXA determined carcass total.

Tissue weights determined by DXA from scans of the live animal and carcass were compared with weights of chemically determined lean tissue (chemlean) and fat (chemfat) (see Table 2). The lean mass in a carcass is predominantly muscle whereas in the live animal lean mass is the sum of muscle, organs, blood and stomach contents, much of which is removed at slaughter to result in a carcass. The correlation between LL and chemlean (r^2 of 0.72) would then be expected to be lower than between CL and chemlean (r^2 of 0.90). The removal of fat deposits such as omental and kidney fat at slaughter also results in a higher correlation between DXA CF and chemfat (r^2 of 0.86) compared to DXA LF which was less correlated with chemfat (r^2 of 0.70). This high correlation between DXA lean/fat mass and chemical lean/fat mass indicates that DXA very accurately predicts muscle and fat weight in a carcass as also shown also by lower RSD’s. Other studies have also shown a high level of prediction accuracy using the DXA on sheep carcasses (Clarke *et al.* 1999; Dunshea *et al.* 2007; Ponnampalam *et al.* 2007) with the highest accuracy being for fat. In this study the highest predictive accuracy was shown for lean tissue

In all these studies however, very specific prediction equations were used which were highly specific to breed (Merino) and weight ranges used in this experiment and consequently the predictive models may not transport well to other breeds or greater weight ranges that fall outside those represented by this study.

Table 2. Models for the prediction of chemically determined lean, fat and bone mass (kg) for live animal and whole carcasses from dual energy X-ray absorptiometry (DXA) determined lean, fat, bone and total mass

Predictors	Best prediction model (values in parentheses are standard errors)	r^2	RSD	F value	Regression significance
Chemlean					
Live Animal	(LL Mean ± SEM = 39.9±0.87 kg)				
	1.99(±1.1)+0.29(±0.02)*LL	0.72	1.05	106.3	**
Whole Carcass	(CL Mean ± SEM = 15.4±0.2 kg)				
	0.66(±0.7)+0.853(±0.04)*CL	0.90	0.64	365	**
Chemfat					
Live Animal	(LF Mean ± SEM = 5.37±0.4 kg)				
	-2.52(±0.23)+0.37(±0.04)*LF	0.70	0.71	86.4	**
Whole Carcass	(Mean ± SEM = 5.14±0.2 kg)				
	-0.46(±0.2)+0.78(±0.04)*CF	0.86	0.42	279.2	**
Chemash					
Live Animal	(LB Mean ± SEM = 1.19±0.03 kg)				
	-0.1(±0.26)+1.17(±0.21)*LB	0.38	0.3	29.8	**
Whole Carcass	(Mean ± SEM = 1.08±0.02 kg)				
	-0.23(±0.27)+1.48(±0.25)*CB	0.39	0.29	31.9	**
BWT / CWT					
Live Animal (BWT)	(LT Mean ± SEM = 46.3±1.1 kg)				
	0.29(±2.46)+0.001(±0.00005)*LT	0.90	2.7	411.5	**
Whole Carcass (CWT)	(CT Mean ± SEM = 21.8±0.5 kg)				
	-0.72(±0.21)+0.001(±0.00009)*CT	0.99	0.17	10954	**

**= P < 0.001, Chemlean= Chemical lean (protein + water), Chemfat=Chemical fat, Chemash= Chemical ash, BWT= Body weight at scanning, CWT= carcass weight at scanning, LF= DXA determined live fat, LL= DXA determined live lean, CF= DXA determined carcass fat, CL= DXA determined carcass lean, LB= DXA determined live bone, CB= DXA determined carcass bone, LT= DXA determined live total, CT= DXA determined carcass total.

Conclusions

Results from this study have shown that the DXA is an accurate tool to measure carcase composition in both live animals and carcasses. DXA determined carcass lean, fat and bone could all be estimated from live DXA scans, with bone being the most accurately predicted. The potential to scan live animals and gain an accurate estimation of carcass composition was identified as a clear benefit. This will enable researchers to better understand the interactions between genetics and environment and the influences they exert on carcase composition. Genetic selection programs may benefit from scanning sheep of high genetic worth through the DXA to improve their rate of genetic gain.

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