Using objective measurement technology to differentiate between lamb ages

Claire E. Payne[1*], Fiona Anderson[1], Graham E. Gardner[1], Liselotte Pannier[1] and David Pethick[2]

[1]Murdoch University, Murdoch, WA 6050, Australia;

[2]Cooperative Research Centre for Sheep Industry Innovation, University of New England, NSW

*Corresponding author email: Claire.payne@murdoch.edu.au

I. INTRODUCTION

Age is a significant contributing factor to eating quality. Increased age has negative impacts on tenderness, odour and flavour in sheep meat. The current Meat Standards Australia (MSA) lamb model uses dentition as a measurement of age but to the variability of tooth eruption it is a poor indicator of both age and eating quality [1], hence a better indicator is required for implementation into MSA.

Dual energy x-ray absorptiometry (DEXA) is currently being installed in processing plants across Australia for the accurate determination of lamb composition and lean meat yield. DEXA images generate R values that correlate with atomic mass of components within the tissue being scanned [2], and therefore may reflect changes in bone mineral content as animals mature. DEXA could be used as an accurate measure of animal maturity/age and could potentially be implemented into the MSA model as a predictor of eating quality. Thus, we hypothesise that DEXA R values within bone tissue will associate with lamb age.

II. MATERIALS AND METHODS

A total of 60 lambs representing two ages (6 months and 12 months) were obtained from the same property and were housed in the same paddock 3 weeks prior to slaughter. At slaughter lambs were DEXA scanned using a commercially installed on-line DEXA scanner at an abattoir in Border Town, South Australia. DEXA images were obtained using a single emission from a 140kV X-ray tube. With each scan a high and low energy image is captured using 2 photodiodes separated by a copper filter as described by Gardner *et al.* [3].

The femur, humerus, radius/ulna and lumber spine (L1-L4) were collected from each carcase for future analysis of bone mineral content. Bones were selected due to ease of collection, image analysis, and the known change in mineral content that occurs with age in these bones [4]. These bones were individually isolated from the DEXA images using Image J (version 1.44p) by tracing around the 4 individual bones within every image. The whole carcase bone measurements were obtained using thresholding values to isolate bone containing pixels from the entire image. R values were calculated for every pixel in both the low energy and high energy images. The DEXA R mean and DEXA R standard deviation (SD) for individual bones and the whole carcase bone was calculated and subsequently used in general linear models (SAS version 9.2, SAS Institute, Cary, NC, USA) to predict differences between the lamb ages.

III. RESULTS AND DISCUSSION

DEXA R for carcase bone and individual bones (lumbar , femur, humerus and unlna/radius), hot carcase weight (HCWT) and GR tissue depth (GR) mean ± SD, minimum, and maximum for are shown in Table 1.

The ability of DEXA to predict lamb age (months) was moderate for the femur (Model 4, Table 2: R2 = 0.59, RMSE = 1.98) but relatively poor for whole carcase bone and other individual bones. In comparison, when HCWT and GR were included in the model together prediction of lamb age was the highest (Table 2: Model 3, R^2= 0.73, RMSE= 1.60). Furthermore, DEXA R mean and DEXA R SD for all bone types became insignificant when HCWT and GR were include in the model suggesting differences in DEXA R values are likely describing differences in fat rather than specifically age. Thus in support of our hypothesis DEXA can differentiate between lamb age, although poorly.

Table 1Carcass data including mean ± standard deviation, minimum and maximum values for carcase bone R, individual bone R (lumbar, femur, humerus, radius/ulnar), hot carcase weight and GR tissue depth.

Age (mo)	Whole carcase bone R ± SD (min, max)	Lumbar R ± SD (min, max)	Femur R ± SD (min, max)	Humerus R ± SD (min, max)	Rad/Uln R ± SD (min, max)	HCWT ± SD (min, max)	GR ± SD (min, max)
6	1.36 ± 0.01	1.39 ± 0.02	1.31 ± 0.01	1.33 ± 0.04	1.41 ± 0.03	22.7 ± 2.23	12.6 ± 4.18
	(1.33, 1.39)	(1.36, 1.42)	(1.29, 1.34)	(1.25, 1.4)	(1.35, 1.46)	(19.4, 31.9)	(5.5, 28)
12	1.35 ± 0.01	1.38 ± 0.02	1.32 ± 0.01	1.32 ± 0.03	1.41 ± 0.03	21.6 ± 1.22	18.4 ± 1.22
	(1.34, 1.38)	)(1.35, 1.41	(1.3, 1.34)	(1.27, 1.38)	(1.34, 1.47)	(19.2, 23.5)	(14.5, 24)

Table 2 F-values, coefficient of determination (R-square), and root mean square error (RMSE) for models predicting age (months) in lamb using DEXA R, DEXA standard deviation, hot carcase weight (HCWT) and GR fat depth (GR).

Model	1	2	3	4	5	6	7	8
Bone	Whole bone	Lumbar	Humerus	Femur	HumRadUln			
				F Values				
DEXA R Mean	12.08*	10.82*	0.27	19.66*	0.09			
DEXA R SD	1.2	8.74*	3.59	0.27	7.68*			
HCWT	-	-	-	-	-	54.07*	-	158.14*
GR	-	-	-	-	-	-	235.41*	339.49*
				Precision estimates				
R2	0.20	0.17	0.08	0.59	0.12	0.10	0.44	0.73
RMSE	2.76	2.81	2.89	1.98	2.86	2.89	2.29	1.60

* P Value <0.0001

IV. CONCLUSION

DEXA scanning currently offers a poor to moderate precision for prediction of age with measured GR tissue depth superior for age prediction. Further experiments will focus on expanding the lamb numbers and range of GR tissue depth and HCWT to explore the ability of DEXA to predict age. Future image analysis techniques will focus on thresholding techniques that better identify bone pixels to uncouple the association of DEXA R with GR tissue depth and carcase fatness. Bones that can be identified as good to predictors of age will subsequently be analysed for bone mineral content to better appreciate the link with lamb age and maturity. An objective measure of lamb age and animal maturity would enable better prediction of lamb eating quality when implemented into the MSA model.

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