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Repeatability of dual energy X-ray absorptiometry (DEXA) measures of beef carcase composition at abattoir line speed (#287)

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Introduction

The Australian beef industry is focused on developing objective carcase measurement technologies to improve the transparency of carcase trading. Processors purchase cattle based on carcase weight and single-site fat measures indicating carcase composition. However, these fat measures are imprecise and inaccurate predictors of whole carcase fatness (Williams et al., 2017). To improve the valuation of lamb carcases in Australia, a dual energy X-ray absorptiometry (DEXA) system was developed to measure carcase composition with high precision and accuracy at abattoir line speed (Gardner et al., 2018). Following this success, the first commercial beef DEXA system was developed and installed in an abattoir. The system can differentiate the chemical fat composition of tissues of varying thickness and thereby produce a DEXA value for beef sides scanned. Before the system is fully calibrated against computed tomography, the repeatability of the DEXA imaging system needs to be assessed. We hypothesise that predictions of carcase composition from the beef DEXA system will be highly repeatable when carcase sides are scanned recurrently over a short period of time.

Methods

Sixty beef sides were selected from Teys Australia Lakes Creek abattoir chiller for repeated DEXA scanning. The sides ranged from 108 to 184 kg, and from 1 to 33 mm in P8 fat depth. Carcases were DEXA scanned in 4 groups of 15 sides. Sides were hung with the medial side facing the X-ray tube and scanned at line speed, before being directed back for repeated DEXA scans a further 5 times in the same order. Each side was thus DEXA scanned 6 times in a 10-15 minute time period. This process was repeated with another 3 groups of 15 sides on the same day.

The DEXA system was comprised of 2 X-ray tubes and 2 detectors, positioned vertically to capture the length of a beef carcase (Fig. 1). X-ray images were generated from each of the 140kV X-ray tubes, with high and low energy images captured on each detector. The detectors consisted of two photodiodes containing ZnSe and CsI scintillants, separated by a copper filter. The upper and lower DEXA images of each beef side were calibrated and analysed separately. An average DEXA value was determined for each image via threshold removal of the bone-containing pixels and by applying relationships previously established between DEXA values, chemical fat % and tissue thickness. The DEXA values were analysed using general linear mixed models in SAS, with beef side identification within group and repeat scan number fitted as fixed terms in the model.

Results

The mean DEXA values for beef sides varied markedly as would be expected given their weight and P8 values. DEXA values ranged from 71.5 to 95.4 in upper detector images, and from 72.8 to 102.5 in lower detector images (Table 1). In line with our hypothesis, the beef DEXA system produced highly repeatable measures of carcase composition (Table 1, Fig. 2 and 3). When beef sides were scanned 6 times within a short time period, the DEXA values calculated from the repeated images had a standard deviation of only 0.36 on average on the upper detector, and 0.40 on the lower detector (Table 1). This variation in DEXA values between repeated scans represents just over 1% of the unit range in DEXA values.

Table 1. The mean and range in DEXA values of all beef sides scanned; and the average standard deviation in DEXA values within beef sides repeatedly DEXA scaned.

Group	Number	DEXA value mean (range)		Mean Standard Deviation of repeat carcase scans	
Upper	Lower	Upper	Lower		
1	15	83.3 (74.5 – 87.6)	86.3 (77.1 – 91.9)	0.31	0.38
2	15	79.7 (71.5 – 85.6)	84.5 (76.3 – 90.9)	0.18	0.26
3	15	88.9 (82.4 – 95.4)	92.7 (85.3 – 102.5)	0.41	0.37
4	15	78.7 (72.3 – 84.1)	81.4 (72.8 – 88.5)	0.48	0.50
Total	60	82.7 (71.5 – 95.4)	86.4 (72.8 – 102.5)	0.36	0.40

Conclusion

In conclusion, the prototype beef DEXA system can produce highly repeatable images of beef sides in a commercial setting. The slight increase in variation between DEXA scans on the lower detector may relate to slight positioning changes in the lower portion of the carcase as it moves along the hook and conveyor during DEXA scanning. The values obtained from both detectors are nonetheless highly repeatable, demonstrating that the system and its components can consistently measure composition of beef sides scanned at abattoir line speed.

1. Williams, A, Jose, C, McGilchrist, P., Walmsley, B., McPhee, M., Greenwood, P. and G. Gardner (2017) Predicting beef carcase composition

Notes

1. from weight and rib fat depth. International Congress of Meat Science and Technology, Cork, Ireland.
2. Gardner, G, Starling, S, Charnley, J, Hocking-Edwards, J, Peterse, J, and A. Williams (2018) Calibration of an on-line dual energy X-ray absorptiometer for estimating carcase composition in lamb at abattoir chain-speed. Meat Science, 144 (91-99).

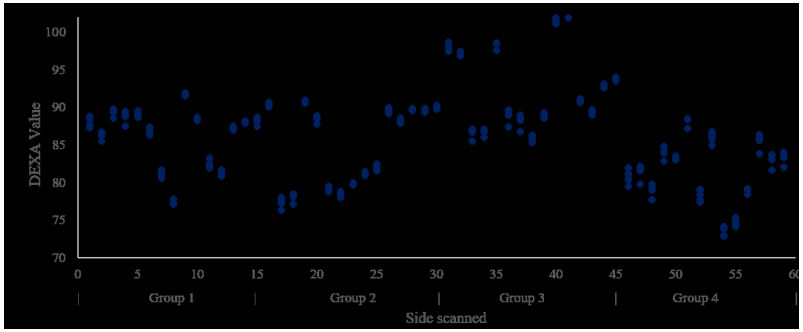

Figure 3. The lower detector DEXA values calculated from 6 repeated DEXA scans of 60 beef sides.

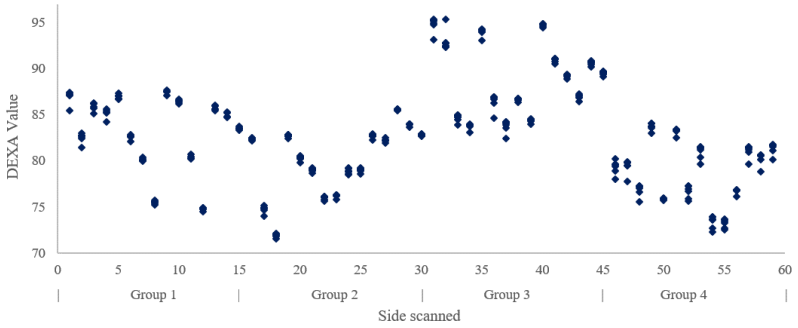

Figure 2. The upper detector DEXA values calculated from 6 repeated DEXA scans of 60 beef sides.

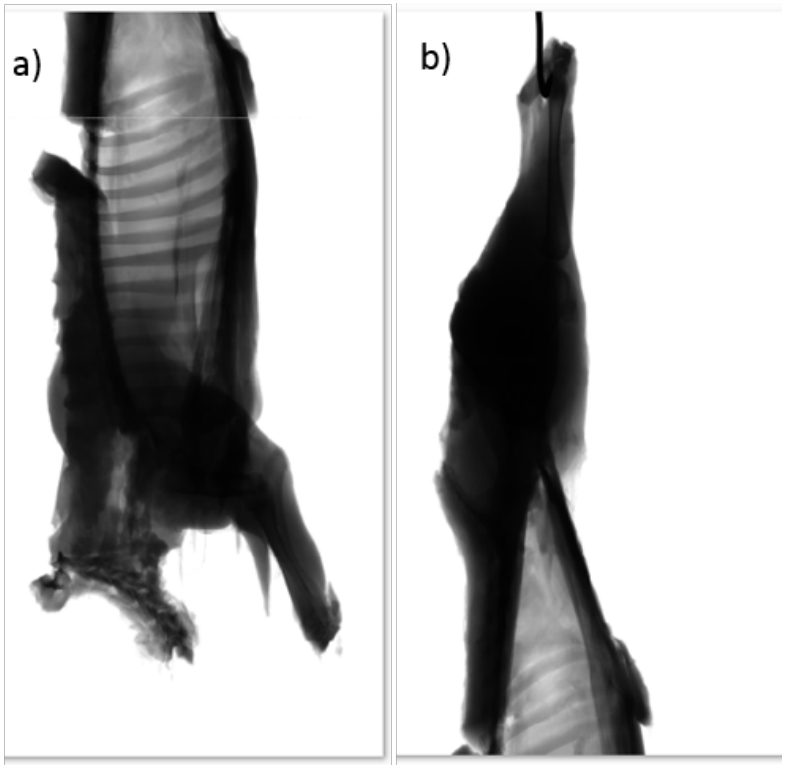

Figure 1. Calibrated a) upper and b) lower detector DEXA images of a beef side scanned at line speed

Notes