DUAL ENERGY X-RAY ABSORPTIOMETRY AS A RAPID AND NON-DESTRUCTIVE METHOD FOR DETERMINATION OF LEAN, FAT AND BONE CONTENT IN LIVESTOCK

Ó. López-Campos[1*], M. Juárez[1], I. L. Larsen[1], N. Prieto[1], J. Roberts[1], M. E. R. Dugan[1] and J. L. Aalhus[1]

[1]Agriculture and Agri-Food Canada, Lacombe Research Centre, Lacombe, Alberta, Canada.

*Corresponding author email: oscar.lopezcampos@agr.gc.ca

Abstract – This manuscript summarized results of ongoing research where dual energy x-ray absorptiometry (DXA) has been used to estimate lean, fat, and bone carcass composition in beef, pork and lamb. A total of 334 beef, 212 pork and 155 lamb carcasses were used to build calibration equations. Left carcass sides were scanned with a Lunar iDXA unit and then dissected into lean, fat, and bone and weighed. PLSR results between actual and DXA estimated lean and fat values showed highly related (R^2>0.97) across species studied, while estimates for bone were less accurate, particularly for pork (R^2=0.889) and lamb (R^2=0.870). The present results suggest that DXA technology has the capability to accurately estimate carcass composition in livestock.

Key Words – bone, carcass cut-out, DXA, fat, lean, yield.

I. INTRODUCTION

The ability to analyze body composition is fundamental for the evaluation of growth efficiency in animal research and for genetic selection in animal production. Body composition analysis is also important for determining carcass market value. Lean meat yield, either total or saleable, is one of the main determinants of beef carcass value in the beef industry. Direct assessment with standard techniques requires full dissection or chemical analyses for measurement of body composition. These manual methods are destructive, time consuming and expensive. In comparison, indirect techniques using linear measures are rapid and inexpensive, but have limited prediction accuracy [1, 2]. Interest in using dual energy x-ray absorptiometry (DXA) in the meat industry has increased due to the low cost per unit, speed of data collection, reliability and ease of use compared with other technologies (i.e. Eagle Product Inspection; SCOTT® Technology Limited). Calibrations and robust equations must, however, be developed in order to implement DXA technology, for the precise, accurate and routine prediction of carcass yields in livestock.

II. MATERIALS AND METHODS

From a wide range of carcasses, a total of 334 beef (230 crossbred finished steers and 104 cows), 212 pork and 155 lamb carcasses were used to build calibration equations within each population. Due to size limitations of the DXA table, for beef carcasses, left carcass sides were fabricated into primals following normal commercial practices. Each primal cut was scanned with a Lunar iDXA unit (GE Lunar Prodigy Advance, GE, Madison, WI, USA) using standard mode/whole body scan option to estimate DXA fat, lean and bone tissues. After DXA scanning, primal cuts were dissected into total lean, fat, and bone and weighed by qualified personnel. Although whole carcass scans were possible for smaller species, to enable cross-species comparisons, primals were also scanned for pork and lamb. Partial least square regressions (PLSR) were used to develop prediction equations with DXA lean, fat and bone from primal cut scans used as independent variables and actual lean, fat and bone used as dependent variables (SAS, [3]). Coefficient of determination (R^2) and root mean square error of calibration (RMSE) were used to assess the predictive ability of models.

III. RESULTS AND DISCUSSION

Previous studies have reported DXA's potential for use as a non-destructive method for determining body composition in cattle, pork and lamb [2, 4, 5]. For the most part, previous studies used DXA scans and body chemical compositions to develop prediction equations using single and stepwise regression models. In the present study, equations were developed using DXA estimates for fat, lean and bone and actual values obtained by full dissection of primals except for pork belly. The proportion of variation in lean and fat accounted for by prediction equations was very high across species (R^2>0.97, Table 1) across species . Within beef, the present results suggest that DXA's capacity to estimate carcass composition is independent of maturity. With regard to bone predictions, PLSR analyses also improved predictions for bone compared to simple regression models previously developed at this institution [2] or or when using single pass scans for pork and lamb. Observed R^2 values for predicting bone were slightly lower than those for lean and fat estimations, particularly in carcasses with smaller bone sizes such as pork (R^2=0.889) and lamb (R^2=0.870). Current DXA units are calibrated for the clinical assessment of bone mineral content and density in humans. Therefore, DXA units currently available are not calibrated to estimate the whole bone content in livestock.

Table 1 Overall relationship (R^2)[a] between dual-energy x-ray absorptiometry values and the traditional carcass cut-out for lean, fat and bone of the different beef, pork and lamb carcasses

Carcass	N	Lean (R^2)	RMSE	Fat (R^2)	RMSE[b]	Bone (R^2)	RMSE
Beef steers	230	0.994	0.0913	0.990	0.1160	0.943	0.2708
Beef cows	104	0.992	0.1182	0.994	0.0987	0.924	0.3285
Pork[1]	212	0.992	0.0954	0.989	0.1133	0.889	0.3674
Lamb	155	0.969	0.2085	0.985	0.1478	0.870	0.4168

[a]R^2: coefficient of determination. [b]RMSE: Root mean square error. [1]Pork manual dissection did not include belly.

IV. CONCLUSION

Results suggest DXA can be reliably used to estimate carcass composition in livestock, with a higher degree of accuracy for lean and fat. Using PLSR analyses, prediction models for research purposes have been developed using data from primal scans. However, further studies to externally validate prediction accuracy, and to obtain calibration curves for specific retail cuts or carcass cut-outs specifications are needed. Prediction accuracies for industry applications using single pass scans will also be needed.

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