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Post-mortem prediction of primal and selected retail cut weights of New Zealand lamb from carcass and animal characteristics

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ABSTRACT

Post-mortem measurements (cold weight, grade and external carcass linear dimensions) as well as live animal data (age, breed, sex) were used to predict ovine primal and retail cut weights for 792 lamb carcases. Significant levels of variance could be explained using these predictors. The predictive power of those measurements on primal and retail cut weights was studied by using the results from principal component analysis and the absolute value of the t-statistics of the linear regression model. High prediction accuracy for primal cut weight was achieved (adjusted R^2 up to 0.95), as well as moderate accuracy for key retail cut weight: tenderloins (adj-$R^2 = 0.60$), loin (adj-$R^2 = 0.62$), French rack (adj-$R^2 = 0.76$) and rump (adj-$R^2 = 0.75$). The carcass cold weight had the best predictive power, with the accuracy increasing by around 10% after including the next three most significant variables.

1. Introduction

With the highest density of sheep per unit area in the world, New Zealand is one of the main exporters of lamb meat with a total value of NZD2.6 billion (Beaf & Lamb New Zealand, 2013), making sheep farming one of its most important agricultural industries. With a trend from producing primal cuts to more complex retail cut specifications for many markets, the production process requires more flexibility to determine the best cutting strategy for each carcass, and thus to maximize the revenue from the carcasses available each day. Improvements in the prediction of primal and retail cut yields are needed to drive process optimization. From 2013 to 2015, Silver Fern Farms, the largest processor and exporter of mutton, lamb, beef and venison in New Zealand, had engaged the Auckland Bioengineering Institute to carry out geometric modeling and statistical analysis work for lamb carcasses. The aim was to build a robust yield predictive model using data from multiple imaging modalities including X-Ray and computed tomography (CT), and to provide theoretical guidelines for future software and hardware implementation.

Prediction of lamb carcass composition using the EUROP classification, carcass shape and length measurements (Kongsro, Røe, Kvaal, Aastveit, & Egelandsdal, 2009) has shown to be very accurate (total muscle weight $R^2 = 0.85$), but did not predict the weight of specific retail cuts as it focused on assessing overall fat, muscle and value in lamb carcasses. The use of linear measurements was judged as being too time consuming and of marginal utility since it was unable to distinguish between lean and fat (Stanford, Jones, & Price, 1998), although the main objective of that study was to predict retail cut weights and not to make a distinction between the lean meat and fat proportions. Another study on the prediction of lamb carcass composition was of interest as it predicted total dissected muscle weights and fat weights using post-mortem measurements (Lambe et al., 2009), but it did not predict individual muscle weights. Similar studies on the prediction of lean meat yield in pigs suggest that lean meat weight is strongly correlated with cold weight and body shape (Andrada, Górriz, & Bote, 2010; Doeschl et al., 2004). However, a study carried out in the cattle industry on beef carcasses was of more interest as it was similar to the present study in terms of using photogrammetry to record linear measurements in predicting the cut weights (Brinks, Clark, Kieffer, & Urick, 1964). Their models have proven to be very accurate, as the prediction of the loin weight reached an R^2 of 0.91. However, as the analysis was conducted on only 38 steers, the results might have been biased, as it did not have a representative randomly chosen population. A statistical study of 443 lamb carcasses, which used video imaging analysis (VIA) for the prediction of carcass composition, concluded that the effects of cold carcass weight was the most significant as it explains 84%-94% of variation; however dimensional measurements were not explicitly used in that model (Rius-Vilarrasa, Bünger, Maltin, Matthews, & Roehe, 2009) but employed conformation score. Another relevant

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Table 1
Distribution of the 792 lamb carcasses amongst the sex and fat categories.

Fatness class[a]	Female	Castrated male	Male	Total
Y (Low)	125	177	139	441
P (Medium)	102	99	83	284
T (High)	14	9	2	25
F (Excessive)	21	14	7	42
Total	262	299	231	792

[a] Based on the fat cover (mm). Grade Y: up to 6 mm, 7 mm, and 9 mm for hot weight (HWT) of 9.1–13,2 kg, 13.3-17 kg, 17.1–21.2 kg, respectively; Grade P: up to 12 mm; Grade T: 12-15 mm; Grade F: over 15 mm.

Table 2
Average cold weight (CWT), age and grade distribution among 4 different breeds: Romney, Perendale, Merino and Corriedale lambs.

Breed	CWT (Kg)	Age (weeks)	Fatness class			
			Y	P	T	F
Romney	18.2	28.5	53.5%	38.6%	2%	5.9%
Perendale	18.5	30.4	33.3%	56.9%	5.9%	3.9%
Merino	17.2	43.9	77.4%	22.6%	0%	0%
Corriedale	17.2	39.1	69.2%	26.9%	0%	3.9%

study based on 268 crossbred lambs used primal cut weights and carcass measures (GR, fat score) to predict meat yield (Siddell, McLeod, Toohey, van de Ven, & Hopkins, 2012). Dimensional measurements were not used in their model either.

This current study was carried out to find the most significant variables that would improve the precision of predicting retail cut weights, using carcass traits and shape measurements, which could be easily captured through X-ray or VIA. Another motivation was that the main dimensions that can be used to enhance the accuracy of the predictions can later be implemented into 3D carcass modeling software (Ho, Hunter, & Pearson, 2013), which serves as an aid to the selection of retail cuts that would maximize carcass value. Furthermore, assessing the influence of the measurements on cut weights is useful for breeding programs that can increase the relative slaughter value of lambs.

2. Materials and methods

2.1. Lamb digital grading (LDG) trial

As part of a LDG project carried out by Silver Fern Farms in 2004, large numbers of lambs were boned out with weights of component parts recorded. Table 1 shows the numbers involved, classified by sex and grade. Table 2 gives the breed, average cold weight (CWT), age and grade of the lamb carcasses in the trial. The selection of carcasses for analysis was designed to have sufficient numbers in different sex/weight/grade cells and therefore the group is not representative of the wider population of lambs processed in Silver Fern Farms. For example, the Y grade carcass percentage in the trial was 56%, whereas this grade accounts for only ~35% of total carcasses in the production lines.

Grading was undertaken according to the standard New Zealand as well as international procedure by a trained operator. Briefly, fat grades from Y to F represented by soft-tissue depth over the 12th rib at a point 11 cm from the midline of the carcass, known as the GR measurement was used. The same fat grading scheme was also described by Rius-Vilarrasa *et al.* (2009) and Siddell *et al.* (2012).

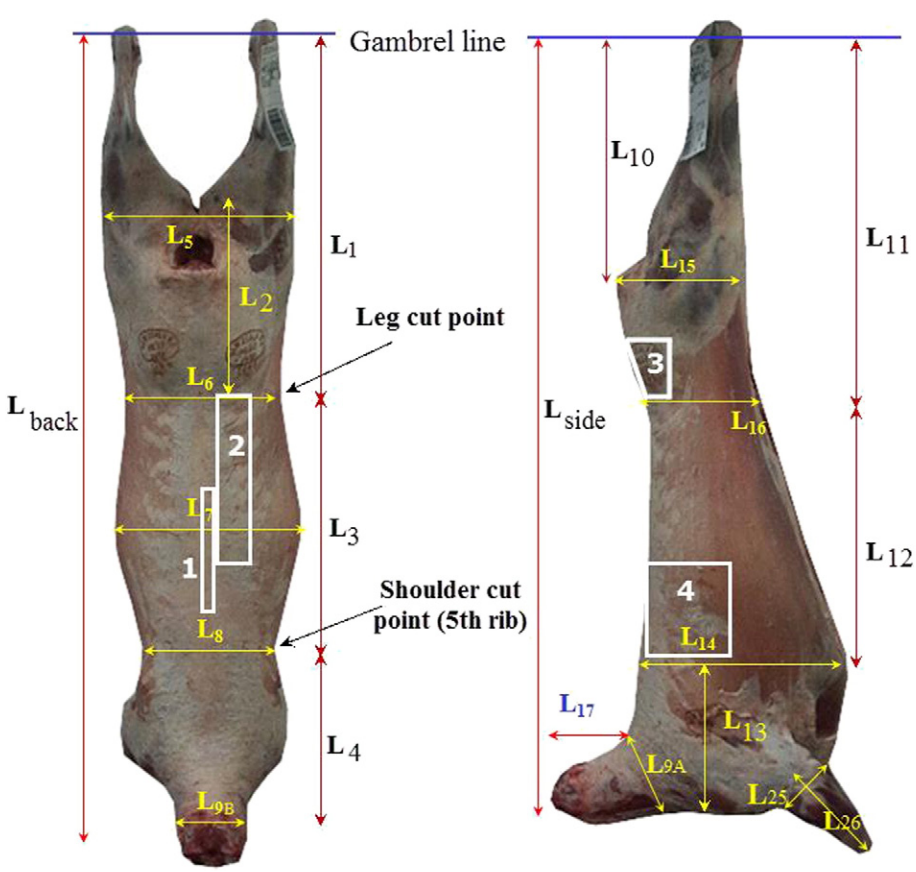

Fig. 1. Position of the shape measurements on the back and side view of the lamb carcass. The description of the dimensions can be found in Table 2. The three primal cuts and the four retail cuts are also shown in the Figure. 1 - Tenderloin; 2 - Loin; 3 - Rump; 4 - French rack. The gambrel line was defined at the bottom of the gambrel where it was in contact with the legs.