Meat Science 98 (2014) 316–320

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Comparison of rankings for lean meat based on results from a CT scanner and a video image analysis system

N.P. Jay [a,*], R.J. van de Ven [b], D.L. Hopkins [c]

[a] *Faculty of Agriculture and Life Sciences, PO Box 84, Lincoln University, Christchurch 7647, New Zealand*
[b] *NSW Department of Primary Industries, Orange Agricultural Institute, Forest Road, Orange, NSW 2800, Australia*
[c] *NSW Primary Industries, Centre for Red Meat and Sheep Development, PO Box 129, Cowra, NSW 2794, Australia*

ARTICLE INFO

Article history:
Received 26 October 2013
Received in revised form 28 February 2014
Accepted 9 May 2014
Available online 17 May 2014

Keywords:
Lambs
Computed tomography
VIAScan®
lean meat yield

ABSTRACT

Coopworth cross lambs born over three years were examined in this study. Differences between two machines; a computer tomography (CT) scanner and a VIAScan® system for the estimation of carcase lean weight in lamb carcases was examined. The CT scanner provided a significantly higher estimate of carcase lean. The rank correlation (0.84) between the CT scanner and the VIAScan® system for the prediction of carcase lean was significant, but there was a different ranking for carcase lean depending on which machine was used. This has important ramifications for the use of VIAScan® data in the New Zealand Sheep Improvement Ltd genetic programme.

1. Introduction

More than 20 years ago studies were undertaken using ultrasound technologies to examine the accuracy with which measures of fat and muscle depth on live sheep could be used to estimate body composition (Hopkins, 1990; Purchas, Rae, Barton, & Beach, 1981). This technology developed to provide real time measures of fat and muscle depth and these measures have been incorporated into sheep breeding programmes in countries like New Zealand (Jopson, Newman, & McEwan, 2009), Australia (Fogarty, Banks, Gilmour, & Brash, 1992) Hungary, Norway and the United Kingdom (Simm, Lewis, Grundy, & Dingwall, 2002). In most terminal meat breeds, the breeding goal is to improve rate of live weight or carcase gain and carcase composition (Macfarlane & Simm, 2007).

In New Zealand computer tomography (CT) has been used as a part of sheep breeding programmes since 1995 (Nicoll, Jopson, & McEwan, 2002) for breeds focused on meat production. A two-stage selection process in combination with ultrasound scanning is used, so that a large number of animals are firstly ultrasound scanned and a proportion of the highest genetic merit animals are then CT scanned (Jopson, Amer, & McEwan, 2004). CT scanning can provide very accurate in vivo estimates of body composition, in particular lean content (Young, Simm, & Glasbey, 2001) and there have been a number of studies which have examined the accuracy levels achievable (Lambe, Young, McLean, Connington, & Simm, 2003; Young, Nsoso, Logan, & Beatson, 1996). CT scans can provide a highly repeatable estimate of carcase tissue weights (Young, Jay, & Jopson, 1999).

More recently with the introduction of video image analysis of slaughtered lambs in some New Zealand abattoirs based on technology developed in Australia (VIAScan®; Hopkins, Safari, Thompson, & Smith, 2004), there has been a move to use data from this system to estimate breeding values for the weight of lean meat within the hindleg, loin and shoulder primal cuts (Jopson, Newman, & McEwan, 2009). Also producers receive information on the percentage of lean meat yield from the hindleg, loin and shoulder meat cuts and the yield payments are based on these measurements and total carcass yield.

Heritability estimates for CT measured lean and fat have been reported as 0.40 and 0.50 (Young et al., 2001), whilst heritability's of 0.20–0.53 for VIA based linear and area measurements have been reported (Rius-Vilarrasa et al., 2010). As such, measurements obtained by either CT scanning or VIAScan® technology will contribute greatly to sheep breeding programmes. The genetic improvement system in New Zealand, Sheep Improvement Ltd. (SIL) allows data from both systems to be entered for genetic evaluation, with the idea of increasing the accuracy of estimated breeding values and rates of selection for carcase composition. However, to date there has been no published data on the comparison between a CT scanner and a VIAScan® system to examine how well their predictions of carcase composition align. It must be stressed that this study was not designed to examine the accuracy of lean prediction from each machine as that has been covered in other

---

* Corresponding author. Tel.: +64 3 325 3838x8623; fax: +64 3 3253618.
E-mail address: Nigel.Jay@actrix.co.nz (N.P. Jay).

http://dx.doi.org/10.1016/j.meatsci.2014.05.006

studies. Therefore this paper outlines an examination of the relationship between such predictions from the two machines and discusses the ramifications of the findings in relation to genetic evaluation and payment systems.

2. Materials and methods

2.1. In vivo measures

In 2011 and 2012, Dorset Down (sire) × Coopworth (dam) mixed sex lambs (based at Lincoln University, New Zealand) were studied. The flock consisted of 150 Coopworth ewes mated to 2 Dorset Down rams in both years. In 2011 ($n = 93$, 47 rams and 46 ewes) lambs ranging in live weight from 30.0 to 54.0 kg (average weight 40.4 kg) were scanned (General Electric CT ProSpeed version 6) by computer tomography (CT). In 2012 another 78 lambs of mixed sex (39 rams and 39 ewes) and ranging in live weight from 29.0 to 45.0 kg (average weight 35.6 kg) were scanned. In both years the lambs were 5 months old at scanning. In 2013, 33 Charollais (sire) × Coopworth (dam) ram lambs (based at Lincoln University, New Zealand) were studied, ranging in liveweight from 28.8 to 42.1 kg (average weight 42.4 kg). These lambs were 6 months of age at scanning.

The animals were removed from food and water for 12 h prior to CT scanning and sedated with an intramuscular injection of 0.1 mg/kg acepromazine maleate (Acezine 10, Ethical Agents NZ), 30 min prior to scanning, under the approval of the Lincoln University Ethics committee. They were scanned lying on their backs with fore and hind limbs extended, restrained and strapped into a cradle. CT scanning was undertaken at seven anatomical reference sites: 7th Cervical, 5th Thoracic, 1st Lumbar, 6th Lumbar, 3rd Sacral, 2nd Caudal and Ischium vertebrae (Kvame, McEwan, Amer, & Jopson, 2004; Lambe et al., 2003). In 2012 scanning at the 7th Cervical site was changed to the 1st Thoracic site (to align with the carcase measurement procedure), with all other sites unchanged. CT scan parameters were kV 120, mA 160, slice thickness 3 mm, field of view 500 mm and scan time 3 s. Image analyses were performed on each resulting reference CT image to separate carcase from non-carcase tissue, using software (STAR; Sheep Tomogram Analysis Routines, V.3.4) (Mann, Young, Glasbey, & McLean, 2003). The carcase tissues were segmented into the three types according to their density value measured in Houndsfield units (HU). HU value ranges were; -174 to -16, -14 to 104 and 106 to 254 for fat, lean and bone, respectively, which were calibrated within STAR. Tissue areas from each scan were converted to volume using the equation, Volume (cm^3) = total area of carcase tissue (cm^2) × section distance (cm) (Roberts et al., 1993). Tissue volumes were converted to weights (kg) using estimated tissue density CT image HU values (True density $= \text{HU} * 0.00106 + 1.0062$; (Campbell et al., 2003)), using the equation:

$$\text{Mass (g)} = \text{Tissue volume}\left(\text{cm}^3\right) \times \text{tissue density}\left(\text{g/cm}^3\right).$$

The weight of lean for each carcase region (shoulder, loin and hindquarter) based on the CT scans was determined. The shoulder region was predicted from the 7th Cervical, (2011) or 1st Thoracic (2012 and 2013) and 5th Thoracic scans, the loin from, the 1st Lumbar, and 6th Lumbar, and the hindquarter, from scans at the 3rd Sacral, 2nd Caudal and Ischium vertebrae.

2.2. Carcase measures

A week after CT scanning in all years the lambs were held off feed and water overnight and transported to an abattoir located two hours away and subsequently slaughtered. From the VIAScan® image data captured at slaughter, predictions of the yield of lean in the three carcase regions using company specific algorithms were obtained. Because of commercial sensitivity accuracy of prediction is not known, but the algorithms are based on measures of carcase dimensions and colour (Hopkins et al., 2004). VIAScan ® predictions of lean meat compared with those based on hot carcase weight and GR gave a greater prediction accuracy of $R^2 = 0.52$ compared with $R^2 = 0.41$ (Hopkins et al., 2004). An estimate of GR (total tissue thickness over the 12th rib, 110 mm from the spine) was also derived from VIAScan® predictions.

2.3. Statistical analysis

A joint analysis of the CT and VIAScan® weight results for lean in the hindleg, loin and shoulder across the animals for all years was undertaken using linear mixed model analysis, and fitted using the *asreml* package (Butler, 2009) under R (R Development Core Team, 2010). In the analysis that follows an adjustment is made to the 2011 results for the loin and the shoulder, relative to the 2012 and 2013 results, as the demarcation plane between the two cuts differed for the 2011 and the 2012–2013 results. Hence, the gain for one cut was a commensurate loss to the other cut. Apart from an adjustment term in the model to accommodate for the modified plane of demarcation between the shoulder and the loin after 2011, the full model fitted for the response variable (Wt) was a linear mixed model having as fixed effects terms for: each site × scan (SS; i.e. HindLeg:VIA, Loin:VIA, Shoulder:VIA, HindLeg:CT, Loin:CT, Shoulder:CT); a separate linear regression on GR for each SS; and a sex effect for each SS. Additive year effects were included in the model as random effects, with a different variance for year effects for each SS level and with year effects equally correlated across levels of SS. This latter constraint was imposed as there were insufficient observations to fit a fully unstructured variance–covariance matrix for year effects. Random residuals in the model were assumed uncorrelated across animals, but correlated across the six SS levels within an animal. To accommodate for the modified plane of demarcation between the shoulder and the loin after 2011 the model also included a covariate, named X1, where X1 takes the value $+1$ for a loin measurement in 2011, -1 for a shoulder measurement in 2011, and zero otherwise. This covariate effect was also allowed to randomly vary across animals included in the study in 2011.

Fitting this model indicated that the regression parameter for X1 was estimated to equal 0.09 (s.e. = 0.10). This indicates that a loin measured in 2011, using the then plane of demarcation plane, gave results 0.09 kg heavier than had the 2012/2013 plane of demarcation been used. The shoulder in 2011 would likewise be 0.09 kg lighter using the 2011 plane of demarcation. A bivariate linear mixed model was fitted to the data for total weight of primals from VIAScan® and CT scan data, where the mean for each trait could possibly differ across the two sexes (ewes and rams) and be linearly dependent on GR. These conditional regression lines are based on conditional normal distribution theory whilst the standard errors of the conditional regression parameters are based on Monte Carlo simulations, simulating from multivariate normal and Wishart distributions. In addition, the mean for each trait was allowed to vary across years and across animals within years. A Spearman's rank correlation was determined within years for the association between lean determined by CT scanning and that predicted by VIAScan®.

3. Results

The average carcase weight of the lambs in 2011, 2012 and 2013 was 17.5 ± 2.6, 13.5 ± 1.7 kg and 20.7 ± 4.5 respectively. A trellis plot of data for the lean weight of the hindleg, loin and shoulder for the three years (2011, 2012 and 2013) as determined via VIAScan® versus the corresponding data obtained via CT scanning is shown in Fig. 1.

Based on the fitted model, adjusting results to the 2012/2013 plane of demarcation between the shoulder and the loin, the average relationship (across years) between VIAScan® and CT scan predictions on the same cuts for animals of the same sex with the same GR were