ESTIMATION OF BEEF CARCASS COMPOSITION USING VELOCITY OF SOUND AND ELECTROMAGNETIC SCANNING

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SUMMARY

The accuracy of Velocity of Sound (VOS) and Electromagnetic Scanning (EMS) technologies was assessed for prediction of lean percentage in beef carcass. VOS, EMS, hot carcass weight and P8 fat depth measurements were taken on carcasses of twenty-eight Hereford x Angus steers, within one hour after slaughter. After overnight chilling, the sides were boned and percent lean was determined chemically. The mean carcass weight and lean percentage were 243 ± 46.8 kg and 66.7 ± 2.6%. The best individual VOS measurement (RV 1 - R^2=0.44; SEE=1.95)) was less accurate than the best combination or average of VOS measurements across two sites (RV 1 and RV 3 - R^2=0.62; SEE=1.60). Predictive accuracy was further improved following the inclusion of carcass weight (R^2=0.70; SEE=1.48). Although small differences in accuracy were observed using individual EMS phase curve parameters, the combination of carcass weight and an EMS height parameter (H_1), was the most accurate (R^2=0.79; SEE=1.21). The advantages in predictive accuracy offered by the two technologies relative to the combination of "standard" carcass measurements (R^2=0.68; SEE=1.49), are at best, only moderate. However, the full potential of each will only be known after they have been assessed on a larger heterogenous sample.

INTRODUCTION

Central to most beef carcass classification schemes is an estimate of carcass composition, particularly the proportion of lean or muscle. Increased emphasis on estimating the quantity of lean in the carcass to determine its value has been motivated by increased consumer demand for leaner beef. The challenge now is to provide accurate, cost effective technologies which, under abattoir conditions, reliably estimate lean content.

Several technologies ranging in cost and complexity are now under development and evaluation. Electromagnetic scanning (EMS) and Velocity of Sound (VOS) are technologies which offer enormous potential in this regard. The objectives of this study were to compare the accuracy of EMS and VOS with the conventional measures of carcass weight and fat depth to predict beef carcass lean content.

MATERIAL AND METHODS

Twenty-eight Hereford x Angus steers were slaughtered at the CSIRO research abattoir. Carcass weight and P8 fat depth (Moon 1980) were recorded immediately after the carcasses had been split into sides. The left side was then measured using the VOS Carcass System (AMAC, Armidale NSW, Australia). Reciprocal VOS measurements (μs/cm) were taken at three sites and these were denoted as:

RV 1 - located between the tenth and eleventh ribs, approximately 6 cm. from the midline. Measurements were taken in a dorso-ventral orientation, parallel to the sawn chine bone.

RV 2 - as for RV 10/11, but between the seventh and eighth ribs.

RV 3 - located immediately cranial to the first rib. Measurements were taken in a medio-lateral orientation.

After completing the VOS measurements, the left side was prepared for electromagnetic scanning Preparation involved reducing the width of the side so that it could be processed through the scanning chamber. The ribs were sawn along the brisket cutting line and the intact brisket was folded into the thoracic cavity. The blade or clod was then partially detached so that the foreleg could be positioned parallel to the spine. Both cuts were held in position by nylon straps. After recording the deep butt temperature and carcass length (between the distal end of the hind leg to the most anterior point on the carcass), the side was conveyed hindleg first through the EMS unit (MQ-25 Meat Analysis System - Meat Quality Inc., Springfield Il., USA) and phase readings were taken at a rate of 10 readings/second. The resultant phase curves were stored for further analysis. Various height and area parameters were extracted from the phase curves according to the following procedure (refer Figures 1 and 2).

(i) The peak phase deflection denoted as H_{PEAK} was located.

(ii) Additional height (phase deflection) parameters were determined by identifying points along its length which were relative to the H_{PEAK} and the two ends of the curve. These parameters were denoted as H_1, H_2, H_3 and H_4.

(iii) Areas under the phase curve were derived by determining those points centred about the peak phase deflection which represent 10%, 30%, 50%, 70%, 90% and 100% of the total length of the phase curve. The areas within these regions were denoted by A_1, A_2, A_3, A_4, A_5 and A_{TOTAL}.

The left sides were chilled overnight, then boned, and the excised soft tissue, comprising of muscle, fat and connective tissue was chemically analysed to determine the percent lean in the side. The data were analysed using the regression procedures of *SAS* (SAS 1988).

Figure 1: EMS phase curve height parameters

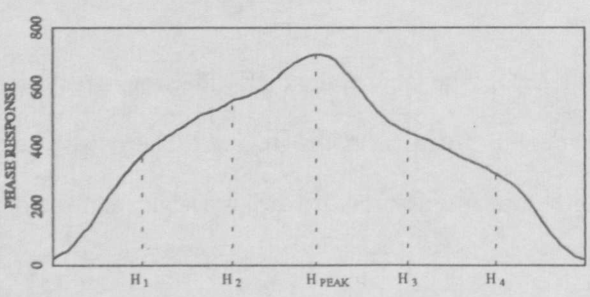
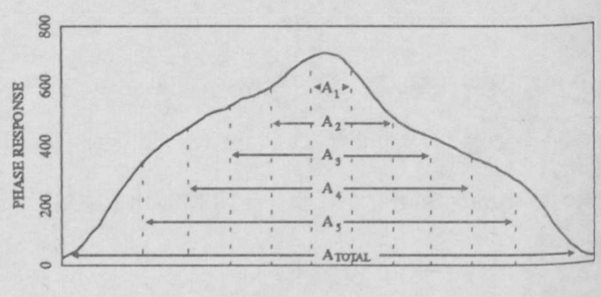


Figure 2: EMS phase curve area parameters



RESULTS AND DISCUSSION

The sample had a mean carcass weight of 243 ± 46.8 kg, P8 fat depth of 10.8 ± 4.6 mm and percent lean of 66.7 ± 2.6%. Regression analysis of the individual VOS and EMS measurements revealed that single measurements were no better than combination of carcass weight and P8 fat depth in the prediction of lean percent (Table 1). It is important to compare accuracy of new technologies against that provided by the combination of "standard" carcass measurements such as carcass weight and fat depth. These measurements are routinely recorded in abattoirs and the accuracy offered by this combination represents the standard which is currently achievable.

The accuracy of the individual EMS phase curve parameters did not vary substantially (Range in R^2=0.24 - 0.31). Of the si site reciprocal velocity measurements, RV 1 accounted for the most variation in percentage lean (R^2=0.44; SEE=1.95%). Mean reciprocal velocity measurements across sites, with the exception of RV 23, were better correlated with lean percent than the best single site measurement RV 1. This finding concurs with those of Miles et al (1987), Miles et al (1990) and Ferguson (1991). The most accurate mean reciprocal velocity measurement was RV 13 which accounted for 62% of the variation in lean percent.

Table 1: **Prediction of beef carcass lean % using "standard" carcass, VOS and EMS measurements**

Carcass Measurements	R^2	SEE
Carcass weight + P8 fat	0.68	1.49
VOS		
RV 1	0.44	1.95
RV 2	0.25	2.25
RV 3	0.26	2.24
RV 12*	0.47	1.90
RV 13*	0.61	1.60
RV 23*	0.34	2.10
RV 123*	0.57	1.70
EMS		
H_1	0.24	2.27
H_2	0.28	2.20
H_3	0.26	2.24
H_4	0.24	2.36
H_{PEAK}	0.27	2.23
A_1	0.31	2.16
A_2	0.31	2.16
A_3	0.29	2.19
A_4	0.28	2.20
A_5	0.28	2.20
A_{TOTAL}	0.28	2.20

* Mean reciprocal velocity across sites

The accuracies of the best EMS and VOS predictive models are presented in Table 2.

Table 2: **Best predictive models based on EMS, VOS and carcass measurements**

Model	R^2	SEE
Carcass weight + P8 fat	0.69	1.49
EMS		
H_1 + carcass weight	0.79	1.21
VOS		
RV 13 + carcass weight	0.70	1.48

The carcass measurements of weight, length and temperature were included in the analyses of the EMS data.

A combination of the EMS phase curve parameter H_1 and carcass weight provided a better prediction of lean percent (R^2=0.79; SEE=1.21) than combinations of carcass weight and other curve parameters. The selection of H_1 is of interest given that it is not located about the peak of the phase curve. In previous studies, parameters closely associated with the peak phase deflection (eg. H_{PEAK}) have usually been selected for the prediction of pork and beef carcass composition (Forrest et al 1991). Preference for parameters such as H_{PEAK} in predictive models is plausible, given that the phase curve reaches a peak when the total lean mass is present within the EMS field. The choice of H_1 might be explained by the fact that this point of the phase curve is principally influenced by the presence of the hindquarter lean mass within the field and this mass would have a dominant effect on the total phase response. The limited nature of the dataset must also be taken into account. The addition of carcass length and/or temperature with H_1 and carcass weight did not significantly improve the predictive accuracy. Carcass length and temperature have been included in other models for the prediction of pork carcass composition (Kuei et al 1989; Kuei et al 1991). However, Forrest et al (1991) reported that neither measurement improved the prediction of lean content in hot beef hindquarters. For the purposes of commercial carcass description, the applicability of this technology would be enhanced if measurements of carcass length and temperature were not required.

A combination of the VOS measurements, RV1 and RV3, or the mean of these measurements provided similar levels of accuracy for predicting lean percent (R^2=0.62; SEE=1.62). However, the addition of carcass weight resulted in an improvement in predictive accuracy (R^2=0.70; SEE=1.48). This agrees with the findings of Miles et al (1987). No further improvement in accuracy was obtained following the addition of a third reciprocal velocity measurement. In view of the time constraints associated with on-line carcass measurement, it would be unlikely that more than two measurements could be taken.

The advantages in predictive accuracy offered by the two technologies relative to the combination of "standard" carcass measurements, are at best, only moderate. It is anticipated that the full potential of these technologies will only become apparent when they are evaluated on a sample comprising of a diverse range in genotypes. Genotypic variations in the distribution of fat between the major carcass depots have been shown to compromise the predictive accuracy of fat depth (Kempster et al 1986). Evidence by Miles et al (1990) has already shown that the relationship between VOS measurements and carcass composition is less influenced by genotype, as quantified in terms of conformation. Furthermore, they were able to remove the effect of conformation, and by implication genotype, by including objective indices of carcass shape which were derived from the VOS measurements. At this stage no comment can be made regarding the effect of genotypic variations of prediction of carcass lean content based on EMS measurements.

CONCLUSIONS

This evaluation of EMS and VOS technologies on a small, homogenous sample of beef carcasses has shown that the best EMS model offers predictive advantages over the "standard" combination of carcass weight and fat depth. The best VOS model was only marginally better than this combination. The overall accuracy and applicability of these technologies within a national carcass description system will only be known after they are evaluated on a larger, more diverse sample.

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