Predicting carcass cut yields in cattle using routinely collected digital images

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Introduction Payment for beef carcasses in the European Union is generally based on a combination of cold carcass weight and classification for carcass conformation and fat. Although, carcass classification in Ireland was originally based on subject assessment by trained personnel, carcass classification is now undertaken in Ireland using authorised classification machines. Since 2005, a copy of two carcass images taken by the VBS2000 mechanical grading machine after slaughter to derive the EUROP conformation and fat grading have been stored in the Irish Cattle Breeding Federation database. The objective of this study was to investigate the potential of using Video Image Analysis (VIA) to predict carcass cut yields.

Material and methods Digital images taken at slaughter can be summarised into 428 variables describing linear measurements of carcass dimensions, carcass contour and carcass color measurements. Two datasets with information on detailed carcass dissections as well as carcass images were treated separately: an experimental (n = 346 steers) and a commercial (n = 281 heifers) dataset. In both datasets, four groups of wholesale cut weights were created, in consultation with industry representatives, according to their retail values: Lower Value Cuts (LVC) including fore- and hind shins, flank, ribs, brisket, neck, and lean trimmings; Medium Value Cuts (MVC) comprising of the shoulder and the chuck cuts; High Value Cuts (HVC) including the sirloin and the round cut weights; Very High Value Cuts (VHVC) comprising of the weights of the rib roast, strip-loin, and fillet cuts. In the experimental dataset, total carcass fat weight and total bone weight were also available. For each of the carcass groups, the two datasets were individually split into a calibration and a validation sub-datasets, based on an equal distribution (i.e., similar mean and standard deviation) of the trait under investigation. In the experimental dataset, 232 steers (67% of the steer population) were included in the calibration dataset and 114 steers were included in the validation dataset; in the commercial dataset, the respective numbers were 189 (67% of the heifer population) and 92 heifers. Three alternative prediction models were evaluated within the experimental and commercial dataset separately: 1) model including carcass weight only, 2) model including carcass weight plus EUROP classification for conformation and fat, and 3) model including carcass weight plus VIA parameters. Stepwise regression, principal component analysis, partial least squares, least angle regression and canonical correlations methods were all separately tested to choose which VIA variables best described the calibration dataset. The regression models developed from the calibration datasets were then applied to the validation dataset and the fit assessed. Statistics used to quantity the goodness of fit in the validation dataset included the mean bias, the RMSE, the coefficient of multiple determination of the model (R^2), and the correlation between the predicted values and the residuals (r_e).

Results Of the alternative statistical methods tested, stepwise regression gave consistently the most accurate prediction; the number of predictors in the model varied from 6 to 10 depending on the trait. Across all traits, the model that included carcass weight plus VIA parameters gave the best prediction as evidenced by the greater R^2 and lowest RMSE. The lack of a residual correlation and mean bias not significantly different from zero implies no systematic bias in the predictive ability of almost all regressions. The large difference in accuracy of prediction of LVC between the experimental and the commercial dataset reflects the differences in cutting procedures between the two plants. The lowest accuracy of prediction was for the VHVC; this is consistent with the fact that VHVC includes the fillet positioned inside the carcass, thus hidden from the camera pictures, and the full loin which can also be difficult to appreciate from a side view image due to its flat shape. Other image technologies (cross section analysis, X-ray tomography) provide a more detailed appreciation of the carcass composition, but at a greater cost.

Table 1 Residual root mean square error (RMSE) and coefficient of determination (R^2) in the validation datasets of the experimental and the commercial dataset using stepwise regression models containing carcass weight (CCW), carcass weight and EUROP grading for conformation and fat (CCW + EUROP), and carcass weight and VIA variables (CCW + VIA)

	Experimental steer dataset						Commercial heifer dataset					
	CCW		CCW+EUROP		CCW+VIA		CCW		CCW+EUROP		CCW+VIA	
Traits (kg)	RMSE	R^2	RMSE	R^2	RMSE	R^2	RMSE	R^2	RMSE	R^2	RMSE	R^2
Total meat	11.78	0.91	7.43	0.97	6.77	0.97	11.31	0.68	9.07	0.80	8.00	0.84
Total fat	10.71	0.33	6.67	0.74	6.38	0.77						
Total bone	4.31	0.66	3.38	0.79	3.22	0.81						
LVC	6.92	0.87	6.54	0.89	5.60	0.92	8.32	0.46	7.35	0.57	6.62	0.65
MVC	3.73	0.74	3.36	0.79	2.73	0.86	1.53	0.62	1.43	0.67	1.37	0.70
HVC	6.03	0.75	3.91	0.89	3.27	0.93	3.16	0.68	2.47	0.81	2.16	0.85
VHVC	2.28	0.74	1.74	0.85	1.75	0.84	1.28	0.68	1.20	0.71	1.24	0.72

Conclusion Inclusion of VIA variables in prediction models improved the fit to the data compared to including only carcass weight or carcass weight and EUROP classification. VIA technology is fast and non-invasive and VIA classification machines are in all Irish cattle abattoirs with the images routinely stored thus providing a powerful tool for exploiting in beef breeding programs.