A COMMERCIAL EVALUATION OF VIDEO IMAGE ANALYSIS IN THE GRADING OF BEEF CARCASSES

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SUMMARY

A total of 450 carcasses were measured for grade fat, loin eye area (tracing and grid) and marbling score (1-10; devoid-abundant). The same measurements were also recorded by video image analysis (VIA). Mean fat thickness was over predicted and loin eye area under predicted by VIA. The standard deviation of the difference for lean % estimated by an approved grading equation using manual and VIA measurements was 1.3%. Repeatability of VIA measurements was 99% indicating a high degree of accuracy. Marbling was poorly predicted from VIA measurements. A rapid manual procedure for assessing beef carcass lean content based on a ruler was also found to have commercial value. It was concluded that VIA had considerable potential to semi-automate the collection of routine carcass measurements to predict carcass lean content.

INTRODUCTION

The identification of beef carcasses with high yields of red meat has become an objective in the national carcass classification or grading schemes of many countries. In North America, the beef carcass is traditionally ribbed (between the 12th and 13th ribs) at 24 h post-slaughter allowing an opportunity for fat thickness and longissimus thoracis area (LTA) to be measured. Murphey et al. (1960) and Abraham et al. (1980) both produced equations to predict red meat yield in beef carcasses and showed that fat thickness, estimated kidney fat and LTA were important dependent variables. Until recently it has not been possible to use yield equations in commercial beef carcass grading due to the lack of equipment to measure fat thickness and LTA on high speed lines (>250 carcasses per h). Cross et al. (1983) explored the use of VIA in the grading of beef carcasses and concluded that it had considerable potential to predict carcass lean content, but this initial work was not continued. During the last decade there have been major advances in the cost, speed of operation, storage capacity and size of microcomputers with the result that VIA may be a practical method for the collection of routine carcass data. The present experiment had the objective of evaluating VIA under commercial conditions as a method to replace the manual grading of beef carcasses.

MATERIAL AND METHODS

Source of carcasses. Carcasses were selected from 4 weight categories (<272, 272-317, 317-362 and >362 kg) and the 4 existing Canadian yield categories (A1-A4) for beef carcasses. The specifications for the 4 Canadian yield categories are a minimum fat thickness of 4-10 mm for A1, 10-15 mm for A2, 15-20 mm for A3 and >20 mm for A4. The carcasses were all accessed in a modern commercial beef processing plant and all measurements were conducted under industrial conditions.

VIA system. The Expert PVS 280S system (Allen-Bradley, Milwaukee, WI, USA) formed the basic hardware components consisting of a camera(CCD), microcomputer, terminal and monitor. The hardware apart from the camera and terminal was enclosed in a stainless steel case which was temperature controlled. In house work was completed to develop a lighting system for the camera, a camera stand to allow the measurement of fat and LTA and the necessary software to complete the carcass measurements.

Carcass measurements. The left carcass sides were first assessed by a grade standards supervisor who measured fat thickness with a ruler to the nearest mm at the grade site (minimum fat thickness). LTA was assessed using a grid (in 1 cm^2 squares). LTA was then traced and later measured with a planimeter along with the recording of maximum LT thickness and length. Marbling score was assessed on a 10 point scale with 1 being abundant and 10 being devoid. The camera stand was placed on the LT and fat recorded at the 3/4 and 5/6 th sites. The VIA system has an accuracy close to 1mm and the measurements are recorded within 5 seconds per carcass. A repeat measurement was also taken to establish repeatability. The camera stand was held as closely as possible to a 90° angle to the cross section of the rib.

Analysis of data. Mean values for the measured carcass variables and for the image variables were calculated. It became apparent that the image measurements for fat were higher than the grade fat and were lower for LTA than assessed by tracing. Consequently, a regression was then computed using the image variables (fat, LTA and carcass weight) and relating them to the lean % from the Canadian yield equation (% lean = 57.34 - 0.032 carcass weight + 0.212 tracing muscle area - 0.681 grade fat Jones et al. 1989). The regression equation was used to assess lean content in each individual carcass. The lean % estimate derived from the Canadian yield equation was compared to the lean % estimate derived from the VIA measurements. The criterion chosen for comparison was the standard deviation of the difference between the generated mean values (Canadian yield equation lean% - VIA lean %). Carcass lean content (% lean) was calculated by the Canadian yield equation and the VIA system across the main weight and yield categories.

RESULTS AND DISCUSSION

VIA fat at the 3/4 or 5/6 positions was higher than the average measured grade fat (Table I). The mean difference ranged from 0.7-1.6 mm depending on the measurement location. This would be expected since the VIA fat measurements would be taken at a position closer to the 3/4 position rather than the grade site (minimum fat thickness). LTA was also smaller as measured by the image system compared to tracings or grid estimates of the loin eye size. These results are different to those of other studies (Cross et al. 1983; Wassenberg et al. 1986) where LTA assessed by VIA has generally been greater than manual measures of LTA. There was good agreement between the tracing and grid estimates of LTA. To overcome this problem (image measurements would always under predict lean % using the Canadian yield equation), the VIA measurements (fat, LTA) were regressed on lean % using the Canadian yield equation substituted with manual measurements to provide the estimate of lean %. The regression equations developed were as follows: % Lean = 57.16 - 0.03 carcass weight + 0.202 image LTA - 0.42 image fat 3/4 (R^2 = 0.82 RSD 1.61%); % Lean = 59.18 - 0.03 carcass weight +0.184 image LTA - 0.52 image fat 5/6 (R^2 = 0.88 RSD 1.36%). Mean values for carcass lean % as by the grading equation and the image measurements are shown in Table II. Although the mean values for lean % are very close to the grading equation for the VIA derived measurements, the important statistic is the standard deviation of the difference. This indicates for the VIA data, using the 3/4 fat measurement, that 65% of the carcasses will be within 1.6% of the estimate for lean content provided by the yield equation. Based on the above analysis, the image equation using the 5/6th fat measurement appears to be the most useful. It is also interesting to note that a standard deviation of mean differences was over 1 for the comparison between using a tracing of the LTA and a grid estimate. Carcasses were grouped into their weight and yield categories and mean lean content assessed (Table III). The VIA equation related well on average to the results from the Canadian yield equation. VIA tended to under predict lean % in A1 carcasses of all weights and over predict lean percentage in fatter carcasses (A3). Repeatability based on the regression of the first vision measurement on the repeat measure for fat, loin eye area and marbling gave R^2 values of 0.99. This indicates a very higher degree of repeatability than achieved in earlier studies (Cross et al. 1983).

The regression of fat % in the muscle assessed by VIA compared to graders score for marbling had a poor association. The R^2 value amounted to 0.14 and indicates that much work will be needed to assess marbling electronically. The marbling score assigned by the grader takes the size and distribution of the marbling deposits into account. Marbling just under the muscle surface can be picked up by the human eye but not by VIA. Similar results were reported by Cross et al. (1983).

For plants not willing to invest in VIA, a rapid method to assess lean content was needed. Work has been completed on the development of a grading ruler. Fat would be measured and LT size categorized into 4 sizes based on LT width (3 divisions) and length (3 divisions).

Table I. Means and standard deviations of VIA and manually measured carcass traits

Measurement	Mean	Standard Deviation
VIA		
Fat thickness 3/4, mm	11.4	5.44
Fat thickness 5/6, mm	10.5	4.79
LTA, cm^2	78.61	11.44
Manual		
Grade fat, mm	9.8	3.9
LTA, cm^2	85.85	11.27
LTA, (grid) cm^2	85.59	11.61
LT length, cm	14.6	0.98
LT width, cm	6.8	0.76

Table II. Mean values for carcass lean % as predicted by the grading equation and vision measurements

System	% Lean	Standard Deviation
Yield equation	58.44	3.85
Yield equation (grid)	58.31	3.71
VIA equation 3/4 fat	58.41	3.54
VIA equation 5/6 fat	58.32	3.63
Yield - grid	0.12	1.05
Yield - VIA 3/4	-0.01	1.60
Yield - VIA 5/6	0.11	1.35

Table III. Mean lean % by carcass weight and grade

		Grade			
Carcass wt	**Equation**	**A1**	**A2**	**A3**	**A4**
<272 kg	Yield	61.8	56.6	51.7	
	VIA	61.2	56.4	55.0	
272-317 kg	Yield	61.2	56.9	52.8	52.0
	VIA	60.9	56.8	54.3	53.9
317-362 kg	Yield	61.2	56.9	51.9	47.3
	VIA	60.8	57.0	52.4	48.1
>362 kg	Yield	61.5	57.6	53.5	
	VIA	61.1	57.2	54.4	

Table IV. Matrix of fat and muscle size to predict lean content.

	Fat mm								
Muscle score	**4-6**	**6-8**	**8-10**	**10-12**	**12-14**	**14-16**	**16-18**	**18-20**	**20-22**
1	61	59	58	56	55	53	52	50	49
2	62	60	59	57	56	54	53	51	50
3	63	61	60	58	57	55	54	52	51
4	64	62	61	59	58	56	55	53	52

There would be 9 fat classes in 2mm increments starting at 4 mm. This gives a lean matrix of 9 fat classes x 4 muscle scores giving a total of 36 potential lean yields (Table IV).

The data collected in this experiment was used to estimate the accuracy of the grading ruler concept. The standard deviation of the difference between lean yield estimated by the Canadian yield equation and lean yield estimated by the grading ruler was 1.44. The lean matrix would be stamped on the ruler so the grader would merely have to assess fat class and muscle score and then read off lean % from the matrix.

Conclusions

1. The VIA approach can be used to assess beef carcass lean content through the recording of fat thickness and LTA . The results conform to those collected on a manual basis. VIA allows for the rapid recording and processing of yield information which is compatible with most commercial situations. VIA will not accurately assess marbling score. VIA can therefore be used not only for settlement purposes with the producer, but also to sort carcasses more efficiently for their potential end use.

2. A rapid manual approach to assessing beef carcass lean content using fat thickness and muscle dimensions has also been developed. While this approach is less accurate than VIA, it is a practical and cost effective system for small plants.

References

Abraham, H.C., Murphey, C.E., Cross, H.R., Smith, G.C. and Franks, W.J. 1980. Factors affecting beef carcass cutability: An evaluation of the USDA yield grades for beef. J. Anim. Sci. 50: 841-851.

Cross, H.R., Gilliland, D.A., Durland, P.R. and Seideman, S. 1983. Beef carcass evaluation by use of a video image analysis system. J. Anim. Sci. 57: 908-917.

Jones, S.D.M., Tong, A.K.W. and Robertson, W.M. 1989. The prediction of beef carcass lean content by an electronic probe, a visual scoring system and carcass measurements. Can. J. Anim. Sci. 69: 641-648.

Murphey, C.E., Hallett, D.K., Tyler, W.E. and Pierce, J.C. 1960. Estimating yields of retail cuts from beef carcasses. 62nd Meeting American Soc. of Anim. Prod., Chicago, Ill.

Wassenburg, R.L., Allen, D.M. and Kemp, K.E. 1986. Video image analysis prediction of total kilograms and percent primal lean and fat yield of beef carcasses. J. Anim. Sci. 62: 1609-1616.