DUAL-COMPONENT VIDEO IMAGE ANALYSIS SYSTEM (VIASCAN™) AS A PREDICTOR OF BEEF RED MEAT YIELD PERCENTAGE AND FOR AUGMENTING APPLICATION OF USDA YIELD GRADES

R.C. Cannell, J.D. Tatum, K.E. Belk, J.W. Wise[1], R.P. Clayton[2], and G.C. Smith

Summary

Improved ability to quantify differences in the fabrication yields of beef carcasses would facilitate application of value-based marketing. This study was conducted to evaluate the ability of the Dual-Component Australian VIASCAN™: (a) to predict fabricated beef subprimal yields as a percentage of carcass weight at each of three fat-trim levels and (b) to augment USDA yield grading, thereby improving accuracy of grade placement. Steer and heifer carcasses (n = 240) were evaluated using VIASCAN™, as well as by USDA expert and online graders, before fabrication of carcasses to each of three fat-trim levels. Expert yield grade (YG), online YG, VIASCAN™ estimates, and VIASCAN™ estimated ribeye area combined with actual and expert grader estimates of the remaining YG factors (adjusted fat thickness, percentage kidney/pelvic/heart fat, hot carcass weight) in an augmentation system, respectively, (a) accounted for 51, 37, 46, and 55% of the variation in fabricated yields of commodity-trimmed subprimals, (b) accounted for 74, 54, 66, and 75% of the variation in fabricated yields of closely-trimmed subprimals, and (c) accounted for 74, 54, 71 and 75% of the variation in fabricated yields of very-closely-trimmed subprimals. VIASCAN™ predicted fabrication yields more accurately than current online yield grading and, when certain VIASCAN™ measured traits were combined with some USDA yield grade factors in an augmentation system, accuracy of cutability prediction was improved, at packing plant line speeds, to a level matching that of expert graders applying grades at leisure.
Key words: Beef, Video, Image, Yield, Grades, Augmentation

Introduction

The U.S. beef industry needs a value-based marketing system, and instrument grading might improve accuracy of assessments of value in such a system; average trading of animals is a major impediment to value-based marketing (Cross and Whittaker, 1992). If the current yield grading system—augmented by VIA technology—could be used to predict, accurately, carcass yields of primal/subprimal cuts at different fat-trim levels, implementation of value-based marketing would be greatly enhanced.

Belk et al. (1998) concluded that application of USDA yield grades could best be augmented by (a) providing an accurate assessment of REA and (b) performing the calculations needed to determine the yield grade accurately at the chain speeds normally encountered in a commercial packing plant. The objectives of this study were to evaluate the ability of the VIASCAN™ system to (a) predict differences in fabricated yields in beef carcasses, and (b) augment the application of USDA yield grades to beef carcasses.

[1] USDA Agricultural Marketing Service, Livestock and Seed Program, Livestock and Meat Standardization Branch, Washington DC 20090-6456
[2] SSI Food Services Inc., PO Box 700, Caldwell, ID 83606

Experimental Procedure

Steer/heifer carcasses (N=240) were selected according to a stratification plan that called for six final USDA yield grade groupings (YG1, YG2A, YG2B, YG3A, YG3B, YG4-5), two sex classes (steer and heifer), and two carcass-weight groups (249 to 339 kg, 340 to 430 kg).

In the Australian Dual-Component VIASCAN™ System, one video camera (Hot Assessment System; HAS) obtains an image of the outside surface fatness and contour of beef sides as they pass by on the rail, and a second video camera (Chiller Assessment System; CAS) records an image of the exposed 12th/13th rib interface.

USDA yield grades (to the nearest full yield grade) were assigned by one of four online graders. In addition, and as an ideal (unlimited evaluation time), yield grades (to the nearest one-tenth yield grade) were assigned by three experts. Carcasses were subjected to VIASCAN™ evaluation twice (HAS on the slaughter/dressing floor and CAS in the grading cooler following chilling for 36h). Carcasses were then fabricated, sequentially, to obtain percentage yields of primal/subprimal cuts at each of the three specified fat-trim levels (commodity-trimmed, closely-trimmed, very-closely-trimmed) by an in-plant, trained and experienced and supervised (by CSU personnel) cutting team.

All statistical analyses were performed using SAS (1988). Regression equations were derived using stepwise selection with maximum R^2 criteria. Mean separations were performed using Tukey's Studentized Range Test.

Results and Discussion

Mean carcass characteristics (Table 1) conformed closely to those reported in the National Beef Quality Audit (Smith et al., 1995); as a result, findings of this study should be applicable across a wide range of U.S. steer/heifer packing and fabrication facilities.

There are undoubtedly hide-pulls and dressing errors that cause the measured fat thickness to be a poor index of general carcass fatness (Abraham *et al*., 1968). Adjustments of fat thickness (Table 1) seem warranted inasmuch as, of all of the expert grader factors and VIASCAN™ measurements, adjusted fat thickness accounted for a higher proportion of the variance in fabricated yields at all three fat-trim levels tested (38.6, 63.5, and 61.5 percent for commodity-trimmed, closely-trimmed, and very-closely-trimmed endpoints, respectively). The improvement in ability (of adjusted fat thickness over actual fat thickness) to predict fabricated yields clearly showed the merit of using adjusted fat thickness when determining USDA Yield Grades (Table 2) and is in agreement with previous findings by Murphey *et al*. (1983).

Ribeye area was significantly correlated with fabrication yields (Table 1) at all three fat-trim levels (coefficients of .53, .59, and .60 for commodity-trimmed, closely-trimmed, and very-closely-trimmed, respectively) in agreement with Abraham *et al*. (1968). CAS ribeye area was slightly more highly correlated (Table 2) than expert ribeye area (measured with a grid) with fabrication yields at all three fat-trim levels.

Of VIASCAN™ measures, CAS estimates (Table 2) of: (a) median fat depth (r = .82) and wholesale yield (r = -.84) were most closely correlated with actual (by expert graders) fat thickness estimates; (b) median fat depth (r = .84) and wholesale yield (r = -.85) were most closely correlated with adjusted fat thickness estimates; (c) ribeye area were very highly correlated (r = .94) with actual ribeye area measurements; (d) other carcass traits were not correlated with KPH fat percentage estimates; and (e) wholesale yields (r = -.89) were highly correlated with final yield grades assigned by expert graders.

Online graders, assigning yield grades to the nearest full yield grade, were able to explain 37, 54, and 54% of the observed variability in cutout yields from carcass sides fabricated to commodity-trimmed, closely-trimmed and very-closely-trimmed product endpoints, respectively (Table 3). George *et al*. (1996) concluded that the current USDA yield grade system is, in fact, an accurate and effective means of predicting carcass yields, and that the inaccuracies in assignment of USDA yield grades to individual carcasses arise from the demands placed on USDA online graders to assign yield grades at extremely high chain-speeds.

Expert-grader assigned yield grade alone accounted for 51, 74, and 74% of the variation in fabrication yields for commodity-trimmed, closely-trimmed and very-closely-trimmed endpoints, respectively (Table 4). In a study of yield grade application accuracy by Cross et al. (1984), a three-member grading panel evaluated 5,582 beef carcasses at 56 plants and found the national percentage error for assignment of yield grades (to the nearest whole yield grade) to be 11.6; in other words, 1 of every 8.6 carcasses that was yield graded had the wrong yield grade number assigned to it. Augmentation (providing estimates of some of these factors to the grader) should free-up the grader and allow more studied estimation of those factors that cannot be estimated or measured by use of VIA technology (like, for example, the adjusted preliminary yield grade).

The best single-component machine prediction was achieved using CAS-WY which accounted for 46, 64, and 68% of the variation in fabrication yields for commodity-trimmed, closely-trimmed and very-closely-trimmed endpoints, respectively (Table 4). The best dual-component machine prediction (Table 4) used both CAS-WY and HAS-WY and achieved yield predictions of 46, 66, and 71% for commodity-trimmed, closely-trimmed and very-closely-trimmed endpoints, respectively.

Online grader applied yield grade accounted for 37, 54, and 54% of the differences in yield for commodity-trimmed, closely-trimmed and very-closely-trimmed endpoints, respectively (Table 4). By combining expert grader yield grade factors of adjusted fat thickness, and KPH fat percentage with CAS estimated ribeye area and hot carcass weight (which could be provided electronically in an augmentation system) in an augmentation model, 55, 75, and 75% of yield variation was accounted for; this level of prediction exceeded the predictive ability of expert-assigned yield grades (Table 4).

Implications

In this study, a prediction model that utilized VIASCAN™ estimates (either alone or in combination with some human grader estimates) more accurately predicted carcass cutout yields than did yield grades assigned by online graders. Based on these data: (a) VIASCAN™ assessments predicted fabrication yields more precisely than yield grades assigned by online graders and approached the accuracy of yield grades assigned by expert graders. (b) An augmentation system combining yield grade factors assigned by expert graders with CAS ribeye area matched the predictive accuracy of yield estimates made by expert graders. (c) VIASCAN™ assessments and/or yield grade factors assigned by online graders could be applied at chain speeds, allowing for yield prediction superior to that achieved by online YG alone.

References

Abraham, H. C., Z. L. Carpenter, G. T. King, and O. D. Butler. 1968. Relationships of carcass weight, conformation and carcass measurements and their use in predicting beef carcass cutability. J. Anim. Sci. 27:604-610.

Belk, K. E., J. A. Scanga, J. D. Tatum, J. W. Wise, and G. C. Smith. 1998. Simulated instrument augmentation of USDA yield grade application to beef carcasses. J. Anim. Sci. 76:522-527.

Cross, H. R. and A. D. Whittaker. 1992. The role of instrument grading in a beef value-based marketing system. J. Anim. Sci. 70:984-989.

Cross, H. R., G. C. Smith, C. E. Murphey, D. M. Stiffler, L. W. Douglass, and J. W. Savell. 1984. USDA beef grades: An evaluation of the accuracy and uniformity of their application. J. Food Qual. 7:107-120.

George, M. H., H. G. Dolezal, J. D. Tatum, J. B. Morgan, J. W. Wise, C. R. Calkins, J. O. Reagan, and G. C. Smith. 1996. USDA yield grades, total body electrical conductivity and video image analysis technologies for predicting cutability of sides of steer/heifer carcasses. Colorado State University 1998 Beef Program Report. p 121-129. Department of Animal Sciences, Colorado State Univ., Ft. Collins.

Murphey, C. E., H. A. Recio, D. M. Stiffler, G. C. Smith, J. W. Savell, J. W. Wise, and H. R. Cross. 1983. Effects of trimming external fat from beef carcasses on the accuracy of determining USDA yield grade. J. Anim. Sci. 57:349-354.

SAS. 1988. SAS User's Guide: Statistics. SAS Inst. Inc., Cary, NC.

Smith, G. C., J. W. Savell, H. G. Dolezal, T. G. Field, D. G. Gill, D. B. Griffin, D. S. Hale, J. B. Morgan, S. L. Northcutt, J. D. Tatum, R. Ames, S. Boleman, S. Boleman, B. Gardner, W. Morgan, and M. Smith. 1995. The National Beef Quality Audit. Colorado State University, Fort Collins, CO, Oklahoma State University, Stillwater, OK, and Texas A&M University, College Station, TX.

Tables

Table 1. Simple correlation coefficients, expert grader and actual yield grade factors, final yield grade and VIASCAN™ system measures vs. actual fabrication yields to three fat-trim endpoints calculated as percentages of intact side weight

			r-values at three cutout yield endpoints[a]		
Carcass measurement or VIASCAN™ factor[b]	Mean	SD	Commodity-trimmed	Closely-trimmed	Very-closely-trimmed
Hot carcass wt (lb.)	741.0	72.5	NS	NS	NS
Ribeye area (in^2)	13.2	1.8	.53	.59	.60
KPH fat (%)	2.39	.55	-.30	-.29	-.30
Actual fat thickness (in.)	.44	.22	-.52	-.70	-.68
Adjusted fat thickness (in.)	.55	.23	-.62	-.80	-.78
Yield grade	2.96	.99	-.72	-.86	-.86
CASFAT	12.24	7.56	-.45	-.59	-.57
CASMDFAT	15.78	6.30	-.54	-.70	-.69
CASREA	90.00	13.32	.56	.60	.61
CASWY	70.66	1.95	.68	.80	.82
HASWY	76.93	.89	.43	.57	.61

[a]Cutout yield endpoint: Commodity-trimmed = subprimal cuts from the four major primals trimmed to 1.0 in. maximum fat depth; Closely-trimmed = subprimal cuts from the four major primals trimmed to .25 in. maximum fat depth; Very-closely-trimmed = subprimal cuts from the four major primals with trim ranging from .25 in. maximum fat depth to denuded.

[b]VIA factors: CASFAT = chiller assessment system ¾ measure fat depth; CASMDFAT = chiller assessment system median fat depth; CASREA = chiller assessment system ribeye area; CASWY = chiller assessment system estimated wholesale yield; HASWY = hot assessment system estimate wholesale yield.

NS = Correlation not significant ($P > .05$)

Table 2. Simple correlation coefficients, VIASCAN™ system measures vs. expert grader factors

ViaScan factor[a]	Expert grader factors: Actual fat thickness	Adjusted fat thickness	Ribeye area	Percentage KPH fat	Expert final yield grade
CASFAT	.79	.71	-.43	.08	.67
CASMDFAT	.82	.84	-.48	.13	.79
CASREA	-.45	-.49	.94	NS	-.71
CASWY	-.84	-.85	.69	-.18	-.89
HASLN	NS	NS	.31	NS	NS
HASWID	.16	.19	.26	NS	.14
HASWY	-.41	-.51	.47	NS	-.58

[a]VIA factors: CASFAT = Chiller assessment system ¾ fat depth; CASMDFAT = Chiller assessment system median fat depth; CASREA = Chiller assessment system ribeye area; CASWY = Chiller assessment system estimated wholesale yield; HASLN = Hot assessment system carcass length; HASWID = Hot assessment system carcass width; HASWY = Hot assessment system estimate wholesale yield.
NS = Correlation not significant ($P > .05$)

Table 3. Simple correlation coefficients, expert yield grade calculated to tenth, whole, and half grades and online grader yield grade vs. actual fabrication yields to three fat-trim endpoints calculated as percentages of intact side weight

Yield grade measure	Cutout yield endpoint[a]		
	Commodity-trimmed	Closely-trimmed	Very-closely-trimmed
Expert YG tenth[b]	-.72	-.86	-.86
Expert YG whole[c]	-.69	-.81	-.81
Expert YG half[d]	-.71	-.85	-.85
Online grader YG[e]	-.61	-.74	-.73

[a]Cutout yield endpoint: Commodity-trimmed = Subprimal cuts from the four major primals trimmed primarily to 2.54 cm maximum fat depth; Closely-trimmed = Subprimal cuts from the four major primals trimmed primarily to .64 cm maximum fat depth; Very-closely-trimmed = Subprimal cuts from the four major primals with trim ranging from .64 cm maximum fat depth to denuded.

[b]Expert YG tenth, yield grade calculated to the tenth of the grade.

[c]Expert YG whole, yield grade calculated to the tenth of the grade, then converted to whole grade (<2.0=1, 2.0 to 2.9=2, 3.0 to 3.9=3, 4.0 to 4.9=4, >4.9=5).

[e]Expert YG half, yield grade calculated to the tenth of the grade, then converted to half grade (<1.5=1.0, 1.5 to 1.9=1.5, 2.0 to 2.4=2.0, 2.5 to 2.9=2.5, etc.).

[f]Online grader YG, yield grade as applied by online USDA graders in whole grades.

NS = Correlation not significant (P > .05)

Table 4. Coefficients of determination for simple and multiple regression models predicting actual fabrication yields to three fat-trim endpoints calculated as percentages of intact side weight

	Cutout yield endpoint[a]					
	Commodity-trimmed		Closely-trimmed		Very-closely-trimmed	
Terms in model[b]	R^2	RSD	R^2	RSD	R^2	RSD
HASWY	.19	1.53	.32	1.83	.38	1.69
CASWY	.46	1.25	.64	1.34	.68	1.21
CASREA CASMEDFAT	.40	1.32	.57	1.44	.57	1.39
HCWT CASREA CASMEDFAT	.46	1.25	.64	1.32	.64	1.27
CASWY HASWY	.46	1.25	.66	1.31	.71	1.16
CASREA HASLN HASWID CASMEDFAT	.44	1.27	.60	1.41	.59	1.38
HCWT CASREA HASLN CASMEDFAT	.46	1.25	.64	1.33	.64	1.28
EXPYG	.51	1.19	.74	1.13	.74	1.09
HCWT REA EXPKPH ADJFAT	.53	1.18	.75	1.12	.75	1.08
HCWT REA ADJFAT	.49	1.22	.72	1.19	.71	1.15
LINEYG	.37	1.44	.54	1.64	.54	1.51
HCWT CASREA EXPKPH ADJFAT	.55	1.15	.75	1.11	.75	1.08

[a]Cutout yield endpoint: Commodity-trimmed = Subprimal cuts from the four major primals trimmed primarily to 2.54 cm maximum fat depth; Closely-trimmed = Subprimal cuts from the four major primals trimmed primarily to .64 cm maximum fat depth; Very-closely-trimmed = Subprimal cuts from the four major primals with trim ranging from .64 cm maximum fat depth to denuded.

[b]Terms in model: CASMDFAT = Chiller Assessment System median fat depth; CASREA = Chiller Assessment System ribeye area; CASWY = Chiller Assessment System estimated wholesale yield; HASLN = Hot Assessment System carcass length; HASWID = Hot Assessment System carcass width; HASWY = Hot Assessment System estimate wholesale yield; HCWT = Hot carcass weight; REA = Ribeye area; EXPKPH = Expert grader estimate of kidney, pelvic, heart fat percentage; ADJFAT = Expert grader adjusted fat depth; EXPYG = Expert grader final yield grade to tenth of the grade; LINEYG = Online grader yield grade to whole grade.