Real Time Augmentation of USDA Yield Grades to Beef Carcasses Using state-of-the-art Video Image Analysis (VIA) Instrumentation

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ABSTRACT

This project was conducted to test the applicability of using two state-of-art Video Image Analysis (VIA) instruments (the Australian VIAscan system, and the Canadian CVS system) to augment USDA line graders assignment of USDA Yield Grades (YG), to a tenth of a yield grade unit, at commercial packing plant speeds. Adjusted preliminary yield grade (PYG), and USDA yield grade were determined by twelve USDA line graders and supervisors for beef carcasses (n = 505) selected in a commercial beef packing plant. Data were compared (5,696 comparisons) to "Gold Standard" yield grades and yield grade factors determined by an expert panel of carcass evaluators given unrestrained time and access to carcasses. The beef carcasses were transferred across the grade chain for each set of USDA line graders twice; the first time the graders assigned a yield and quality grade as done normally, and the second time the graders assigned an adjusted PYG and a quality grade to each carcass. In addition, the two VIA instruments measured the ribeye area of each carcass on the grade chain. At the completion of the trial personnel from Colorado State University removed the kidney, pelvic, and heart fat (KPH) and determined the actual KPH percentage. Online USDA grader PYG were closely related (r = 0.83) to Gold Standard adjusted PYG's. VIAscan and CVS measured REA also were closely related (r = 0.88 and 0.94, respectively) to Gold Standard REA measurements. Two augmented yield grades were tested. The first was comprised of a line grader adjusted PYG, actual KPH percentage (simulating KPH removal and weighing on the slaughter floor), VIA measured ribeye area, and actual hot carcass weight. The second augmented YG was the same as the first, except KPH percentage was eliminated. Augmenting application of USDA yield grades, either by including actual KPH percentage, or neglecting it, were closely related (mean absolute error of .32 and .40 yield grade units; r = 0.93 and 0.92, respectively using VIAscan measured REA; mean absolute error of .24 and .34 yield grade units; r = 0.95 and 0.94, respectively using CVS measured REA) to Gold Standard yield grades. These results indicated that VIA systems can be used to help augment USDA Yield Grades at on-line chain speeds, and that using VIA technology to augment USDA line graders introduces the possibility of accurately assigning yield grades to a tenth of a yield grade unit in real time.

INTRODUCTION

When USDA yield grades are assigned by trained carcass evaluators that are provided with ample time to measure and accurately determine yield grade factors, resulting calculated yield grades have been shown to be effective in estimating beef carcass composition--accounting for approximately 70-80% of the variation in beef carcass cutability. If beef carcasses could be yield graded at commercial chain speeds, within 0.1 yield grade units (as opposed with the current method which results in assignment of grades in whole grades) with the accuracy of "expert" graders, the sorting capability of such a system would provide economic benefit to the packing companies. However, because beef carcasses are presented to online graders in packing facilities at speeds (200-450 hd/hr) that contribute to grading error, such sorting capability is currently not feasible for commercial packing companies using traditional grading techniques.

Therefore, a strong argument can be made to introduce instrument assessment systems into commercial packing facilities that augment the USDA graders. Belk et al. (1996) concluded that, when scientific consensus is established that a specific instrument is capable of replacing USDA graders, technologies could "augment" application of federal beef carcass grades; i.e., allow USDA graders to provide input that is not currently reproducible with an instrument, while allowing an instrument to provide information that cannot be evaluated accurately by graders and to make the time-sensitive computations required at commercial chain speeds. Research has suggested that such a system is currently viable. Both the availability of technology and acceptance of both USDA-AMS and packers clear. As a "stop-gap" measure, such "evolution" of instrument assessment would contribute to the long-term viability of the grading process and other services provided by USDA-AMS, and would allow AMS to continue to standardize application of cutability sorting criteria to beef.

This study was designed to determine the effectiveness of using VIA technology to augment line grader application of USDA yield grades to a tenth of a yield grade unit.

MATERIALS and METHODS

During the course of this study, 505 carcasses were selected on a commercial packing plant grading chain (252 carcasses during week 1, and 253 carcasses during week 2) by USDA and Colorado State University (CSU) personnel over a two week period. Carcasses were excluded from the study if they had been improperly ribbed, exhibited bruises or other defects that affected the *longissimus* muscle, or were not eligible for USDA yield grade application. Carcasses were otherwise selected to represent the normal, mine-run variability in yield and quality traits encountered by the cooperating facility, and selected carcasses exhibited a wide range of cutability and quality determining characteristics. Carcasses selected for inclusion in the study bypassed the USDA graders and were placed on predetermined holding cooler rails.

An expert panel of USDA-AMS (Livestock and Seed Program) beef carcass evaluators were provided

ample time and access to all carcasses to determine Official "Gold Standard" grade factors including the PYG for each side of the carcass, adjusted PYG, KPH, HCW, overall maturity, and marbling score. In addition, CSU personnel measured the ribeye area of both sides of each carcass twice. The average of the two ribeye measurements for each carcass side was used as the "Gold Standard" ribeye area for each.

After all "Gold Standard" measurements were determined for each carcass, the carcasses were transferred across the grade chain, at normal production speeds (~ 400 head/hour; 1 carcass/9 seconds), for a group of four to six USDA line graders. The USDA line graders assigned each carcass a yield and quality grade, as is the current practice in commercial packing plants. Following the completion of this first-transfer, all carcasses were transferred across the grade chain a second time. During the second run, USDA line graders assigned each carcass an adjusted PYG and a quality grade, as they would in an augmented system. For both runs, CSU personnel recorded the grades and/or adjusted PYGs assigned to each carcass by each individual grader (allowing for 5696 comparisons to the "gold Standard"). The graders were asked to assign quality grades to each carcass to simulate the amount of time a grader would have to assign both yield and quality grades. Thus, whether or not graders could more accurately assign quality grades to carcasses in an augmentation system, since they would have more time to evaluate quality factors could be tested. This process was repeated for different groups of USDA line graders until twelve graders had evaluated all carcasses included in the study each week.

Two state-of-the-art VIA systems (the Australian VIAscan and the Canadian CVS systems) were installed on the grade chain of the commercial packing facility. Each of these systems recorded an image of and measured the size of the ribeye of both sides of the carcass each time it was passed across the grading chain.

Finally, after the carcasses had been graded the last time, personnel from CSU removed the KPH fat from each carcass and weighed it in order to determine the actual KPH fat percentage for each carcass. This simulated removal of the KPH fat on the slaughter floor to determine the actual KPH fat percentage for use into an augmented yield grade system.

To ensure that the REA measurements made by the two VIA systems were accurate, SAS statistical software was used to develop a linear regression model to linearly shift each of the instrument REA measurements to more accurately modeled the Gold Standard REA (a practice that would be appropriate for applied use of the VIA systems in a yield grade augmentation system).

Two separate yield grade augmentation methods were evaluated in this study. The first computed the USDA yield grade (using the short-cut USDA yield grade equation used by USDA graders) based on USDA line grader adjusted PYG, actual KPH percentage, machine measured REA (separate yield grades computed for VIAscan and CVS measurements) and actual HCW. The second method was the same, except that the KPH percentage was replaced with an average KPH yield grade adjustment (minus 0.3 yield grade units). This replacement was to determine how much KPH percentage effects yield grade accuracy. The SAS statistical package was used to determine simple correlation coefficients between the online grader estimates and Gold Standard yield grade factors. In addition, mean absolute errors between each augmentation method and the Gold Standard yield grades were computed.

RESULTS and DISCUSSION

Gold Standard population means (n = 505) and variation are shown in Table 1. To determine how representative the test population was of the national beef supply, carcass quality and yield grades were compared to carcasses produced during 1999. It is apparent that the sample population used in this study typified the wide range of differences in carcass composition and quality produced commercially in the United States.

Simple correlation coefficients between "Gold Standard" measures and augmented yield grade factors provided by online USDA graders and the VIA systems are shown in Table 3. Online grader's whole number yield grades were moderately correlated (r = 0.77) to "Gold Standard" whole number yield grades, suggesting that augmentation may improve the accuracy of yield grade assignment to beef carcasses. Simple correlations (Table 3) between online graders adjusted PYG and "Gold Standard" adjusted PYG measurements suggested that online graders are capable of accurately (r = 0.83) assigning adjusted PYGs to beef carcasses in a real time augmentation. Additionally, simple correlation coefficients between VIA measured ribeye area and "Gold Standard" ribeye area were high (r = 0.88 and 0.94 for the VIAscan and CVS systems, respectively). Since Belk *et al*. (1997) demonstrated that ribeye area was the yield grade factor which held the most promise for replacement in an augmentation system, it appears that VIA technology is a viable tool for accurately measuring ribeye area of beef carcasses in an online augmentation system.

Belk *et al*. (1997) also found online grader estimates for KPH percentage were only marginally related (r = 0.66) to "Gold Standard" KPH percentages. Thus, for this study online graders were not asked to estimate KPH percentages online. Instead, the actual KPH percentages, were substituted into the augmentation system to test the effectiveness of KPH fat percentage as a tool for estimating yield grades of. Simple correlations for the augmented versus "Gold Standard" yield grades are shown in Table 4. Mean absolute errors for the augmented versus "Gold Standard"

yield grades are shown in Figure 1. Yield grade augmentation systems utilizing the "Gold Standard" adjusted PYG in conjunction with actual KPH fat percentages, actual HCWs, and VIA measured ribeye area was highly related to "Gold Standard" yield grades (r = 0.97 and 0.98, mean absolute error = 0.20 and 0.14 yield grade units for VIAscan and CVS systems, respectively). Replacing actual REAs with VIA estimates resulted in an accurate assignment of yield grades to a tenth of a yield grade unit. When expert adjusted PYGs were replaced with USDA line grader adjusted PYGs, augmented yield grades were highly correlated (r = 0.93 and 0.92, and mean absolute errors = 0.32 and 0.24 for VIAscan and CVS systems, respectively) to "Gold standard" yield grades. Removal of KPH fat percentage from the calculation of yield grades (substituting mean KPH fat percentage adjustment of minus 0.3 for each carcass in order to maintain the numerical integrity of USDA yield grades) lowered the accuracy of augmented yield grades by only 2-4%. Yield grades calculated to a tenth of a yield grade unit could be more accurately applied to beef carcasses with KPH percentage determined on the slaughter floor, but removing KPH fat percentages from the equation is a viable alternative.

In the augmented yield grade system, line quality graders would only have to estimate the adjusted PYG of beef carcasses, and not all factors that determine final yield grade. As a result, graders would have more time to evaluate the quality characteristics of each beef carcass on the grade chain. Line grader quality grade accuracy, however, did not improve (data not presented in tabular form) when graders were asked to evaluate only the adjusted PYG of each carcass. Augmenting the application of yield grades does increase the accuracy of yield grade placement, but does not influence the accuracy of quality grade placement.

IMPLICATIONS

USDA line grader adjusted PYG estimates (r = 0.83) and VIA measured ribeye area (r = 0.88 and 0.94, respectively) were closely related with expert "Gold Standard" adjusted PYGs and ribeye areas when determined at chain speed. Augmented yield grades that utilized online grader estimates for adjusted PYG, and VIA measured ribeye area were accurate (r = 0.92 to 0.95) when compared with expert "Gold Standard" yield grades. Removal of KPH fat percentage from the augmented yield grades resulted in decreased accuracy of 2-4% compared with expert "Gold Standard" yield grades. Therefore, it appears that VIA technology is a viable tool for increasing the accuracy of USDA yield grade application, since in an augmented yield grade system, yield grades were more accurately (r = 0.92 to 0.95) reported to a tenth of a yield grade unit.

Line grader quality grade accuracy, when only adjusted PYGs and quality grades were assigned at chain speeds, did not improve when compared with online grader accuracy for assignment of whole number yield and quality grades.

LITERATURE CITED

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Table 1. Gold Standard means, standard deviations, and ranges for the sample population (n = 505)[a].

Trait[b]	Mean	Standard Deviation	Min	Max
Overall Maturity	63.1	11.0	50	140
USDA Quality grade[c]	Se[94]	65.7	St	Pr
Preliminary Yield Grade	3.0	0.5	2.0	4.8
Adj. Preliminary Yield Grade	3.3	0.5	2.0	4.5
Percent Kidney, Pelvic and Heart Fat	2.1	0.6	0.5	4.0
Ribeye Area	14.5	1.8	9.4	20.3
Hot Carcass Weight	795.3	88.0	541	1037
Gold Standard Yield Grade	2.8	0.9	1.0	5.0

[a]The total number of comparisons that was allowed was 5696.
[b]PYG = preliminary yield grade; REA = ribeye (*longissimus*) area at the 12th rib interface; KPH = percentage of kidney, pelvic and heart fat; HCW = hot carcass weight.
[c]In percentages of a USDA grade: Std = Standard, Se = Select, Ch = Choice, Pr = Prime.

Table 2. Percentage of carcasses within the sample population qualifying for various yield and quality grades and the national averages for the year 1999.

QG	Percent in Study	1999 Average[a]	YG	Percent in Study	1999 Average[b]
Prime	0.4	3.2	1	21.4	11.6
Choice	34.7	55.7	2	33.5	48.1
Select	62.6	36.3	3	34.6	38.6
No Roll	2.4	4.8	4	10.3	1.7
			5	0.2	0.1

[a]Percentage of all carcasses produced during 1999 that qualified for each of these quality grade designations.
[b]Percentage of graded carcasses produced during 1999 that qualified for each of these yield grades.

Table 3. Simple correlation coefficients between Gold Standard yield grade factors and online estimates.

	Expert Adj. PYG	Expert REA	Expert YG
Line YG			0.77
Line Adj. PYG	0.83		0.77
VIAscan REA[a]		0.88	-0.57
CVS REA[b]		0.94	-0.75

[a]Ribeye are measured online using the VIAscan video imaging system.
[b]Ribeye area measure online using the CVS video imaging system.

Table 4. Simple correlation coefficients between Gold Standard and augmented online yield grades (n = 5696 comparisons).

Adj. PYG[a]	REA[b]	KPH[c]	HCW[d]	r
Expert	CVS	Actual	Actual	0.98
Expert	CVS	None	Actual	0.97
Grader	CVS	Actual	Actual	0.95
Grader	CVS	None	Actual	0.94
Expert	VIAscan	Actual	Actual	0.97
Expert	VIAscan	None	Actual	0.95
Grader	VIAscan	Actual	Actual	0.93
Grader	VIAscan	None	Actual	0.92

[a]Adjusted preliminary yield grade as either estimated by USDA graders at chain speeds (grader) or calculated by the expert panel (expert).
[b]Ribeye area as estimated online by the Australian VIAscan system (VIAscan) or by the Canadian CVS system (CVS).
[c]Kidney, pelvic, and heart fat percentage as determined by removal and weighing of fat (actual) or a set adjustment of minus 0.3 yield grade units (None).
[d]denotes hot carcass weight.

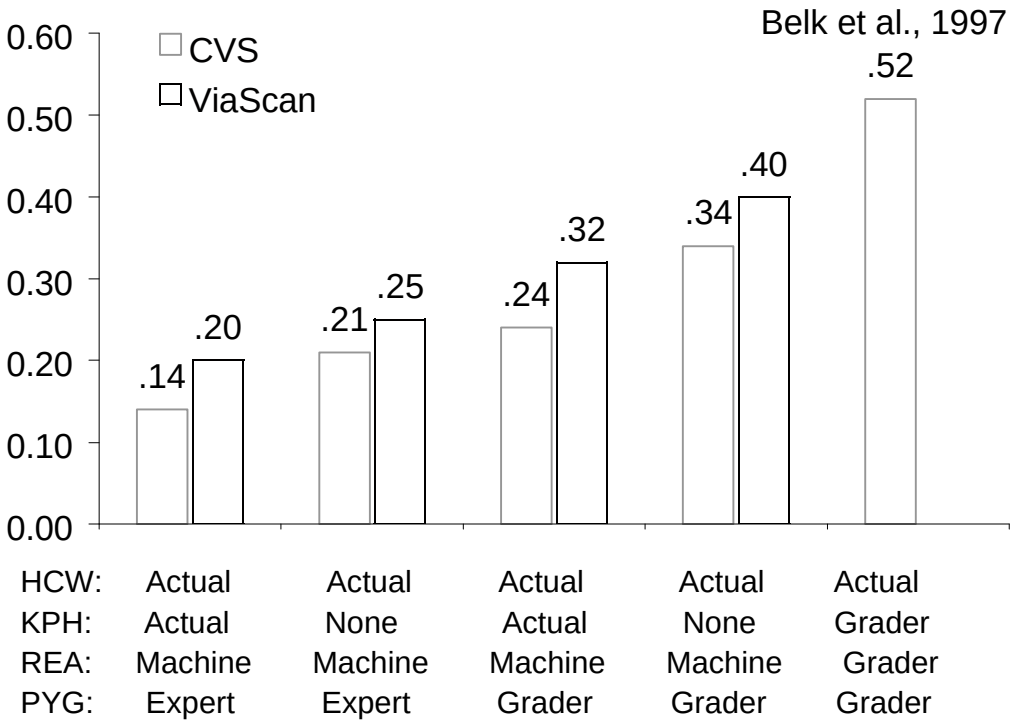

Figure 1. Mean absolute error rates (in yield grade units, on either the positive or the negative side of the Gold Standard value) for augmentation systems estimating the USDA yield grade of beef carcasses.