Color Video Image Analysis for Augmenting Beef Carcass Grading

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Story in Brief

Graders in commercial packing plants have approximately 9 to 18 seconds to subjectively evaluate beef carcasses for yield and quality grade attributes. This strenuous pace coupled with extreme variation in product may result in inconsistencies and errors associated with subjective evaluation. Therefore, instrumentation is needed to objectively assess quality grade and yield grade attributes more efficiently and accurately. Recent advances in full color processing equipment provide video image analysis (VIA) the potential to achieve this accuracy. In this study, 40 steaks were evaluated with color video image processing for marbling percentage and color score. Expert graders also visually evaluated the steaks for marbling and color scores. Proximate analysis for chemical lipid percentage was obtained for comparisons with VIA marbling percentage and expert marbling score expressed as a percentage. Paired t-tests were used to compare VIA color scores with expert grader color scores. Results revealed that VIA measurements and expert grader estimates were positively correlated with lipid percentage. Furthermore, VIA color score was strongly associated with expert grader color evaluations. VIA was shown to offer significant potential for augmenting beef carcass grading by providing fast, objective information for on-line graders.

(Key Words: Beef, Quality Grading, VIA, Color, Marbling.)

Introduction

Industry applications of USDA beef quality and yield grades (USDA, 1997) require subjective estimates determined by trained personnel under extreme "on- line" time constraints. Chain speeds in the commercial industry may range from 200 to 400 carcasses per h, allowing only 9 to 18 seconds to evaluate all of the necessary carcass traits and stamp the carcasses with the appropriate grades. Furthermore, USDA graders evaluate carcasses with extreme differences in carcass weight, external fat thickness, ribeye size and marbling. Therefore, it is logical that grading errors and inconsistencies may occur under these conditions.

As a result, the 1994 National Beef Instrument Assessment Plan (National Livestock and Meat Board, 1994) addressed the issue of instrument grading to objectively predict quality and yield grade attributes. This type of automation should be accurate, repeatable, capable of operating "on-line," and tamperproof. Video image analysis was given top priority for applied research in this area.

VIA was first introduced in 1979 in cooperation with the USDA and National Aeronautics Space Program as a possible mechanism for objectively evaluating carcasses. Initial research was conducted by Cross et al. (1983) with a black and white camera to predict composition of rib sections. More recently, research was completed by Gardner et al. (1995) correlating black and white VIA measurements, expert grader yield grade, USDA yield grade and actual yield grade. This research concluded the addition of VIA technology in combination with USDA grader estimates improves the accuracy of yield grade prediction. However, quality grade prediction was not achievable with this camera.

Recent advances in full color image processing provide VIA the potential to achieve accurate quality grade prediction. Accuracy is critical when predicting yield or quality, especially as value-based marketing becomes a more viable method for marketing cattle. Therefore, there is need to evaluate the application of color VIA for determining ribeye area, muscle color and marbling characteristics.

Materials and Methods

Steaks (n = 40) were obtained from a commercial processing plant in Arkansas City, KS. Criteria for choosing the steaks included variation in marbling, lean color, and ribeye size. Two steaks (1 in thick) were removed from the loin end of a 112A ribeye roll, lip-on. The first steak was designated for chemical analysis while the second steak was identified for visual analysis.

Chemical Analysis. Steaks were denuded of external fat and connective tissue and stored at -4° F. Steaks were frozen in liquid nitrogen and powdered in a Waring blender for proximate analysis. Samples were oven dried to determine moisture percentage prior to 24 h ether extraction to determine actual chemical lipid content on a percentage basis.

Visual Analysis. Steaks were overwrapped in styrofoam trays and chilled at 36° F for 2 to 3 h prior to evaluation. For imaging, steaks were placed in a lighting chamber under diffuse, halogen illumination. A MicroImage A209 RGB color video camera, FlashPoint 128 videographics frame grabber and Pentium Pro 200Mhz microcomputer were used to capture steak images. Processing software for determining marbling percentage and color score was developed using Optimus 6.1 with ALI programming.

Steak images were individually processed by segmenting the *longissimus dorsi* (ribeye) muscle from the surrounding external fat and seam fat, along with the *multifidus dorsi, spinalis dorsi,* and *longissimus costarum* muscles. The segmented ribeye muscle was divided into quartiles to determine marbling percentage and distribution by measuring muscle area and marbling as a percentage of each muscle area. Overall marbling percentage was identified from the whole ribeye muscle as a percentage of the entire ribeye area.

Color scores were determined from three color bands (red, green and blue) and normalized on a scale of 1 to 8 according to Ray et al. (1989). Color scores and marbling percentage were calculated in 5 seconds.

Prior to VIA assessment, two expert graders evaluated steaks independently for USDA marbling score and color score (Ray et al., 1989). Marbling score was converted to a percentage value to compare actual chemical lipid percent and VIA marbling percent.

Statistical Analysis. Paired t-tests were completed to compare actual chemical lipid percentage with both expert graders and VIA assessment of marbling as well as expert grader color scores vs VIA color assessment. Simple correlations were calculated for marbling fat percentages as well as color scores. Regressions were performed to predict actual chemical lipid percentages and expert grader color scores. Frequency distributions were calculated to observe error rate for both marbling and color.

Results and Discussion

Statistics for marbling percentages and color scores are reported in Table 1. Paired t-tests revealed that VIA marbling percentage was similar ($P>.05$) to expert grader marbling percentage; however, both VIA marbling percentage and expert grader marbling percentage were different ($P<.05$) from actual chemical lipid percentage. Simple correlations show VIA assessment for marbling percentage was positively associated with chemical lipid percentage ($r = .49$) and expert graders' marbling percentage ($r = .40$). Both measures are significantly correlated ($P<.01$), even though expert graders marbling percentage had a higher correlation with chemical lipid percentage ($r = .75$).

Frequency distributions for VIA marbling percentages compared with actual chemical lipid percentages and expert grader marbling percentages are shown in Figure 1. Of the 40 steaks evaluated, 52.5% of the VIA measurements were within .5% and 72.5% were within 1.0% of actual chemical lipid percentage values. Expert grader assessment of marbling resulted in 72.5% of the evaluations within 1.0% and 40% within .5% of VIA marbling percentage values.

VIA assessment of color was strongly associated ($r = .90$; $P<.01$) with expert grader color scores. The frequency distribution (Figure 2) revealed 42.5% of expert grader evaluations were within half of a color score, 90% were within one color score and 10% differed by more than one color score.

Implications

Results indicate that VIA has the ability to evaluate quality characteristics of beef carcasses. It provides the beef industry with possible instrumentation to assist current on-line grading. This instrumentation could enhance accuracy and consistency of quality grade assignments, and as a result could become a major factor as the beef industry moves toward value-based marketing.

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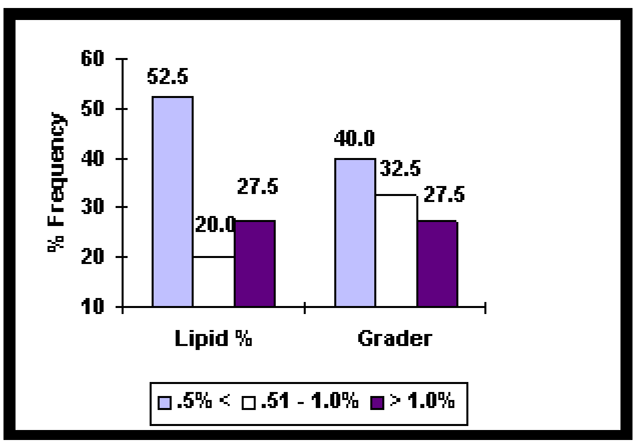

Figure 1. Frequency distributions of absolute differences between VIA marbling percentages compared with actual chemical lipid percentages and expert grader marbling percentages.

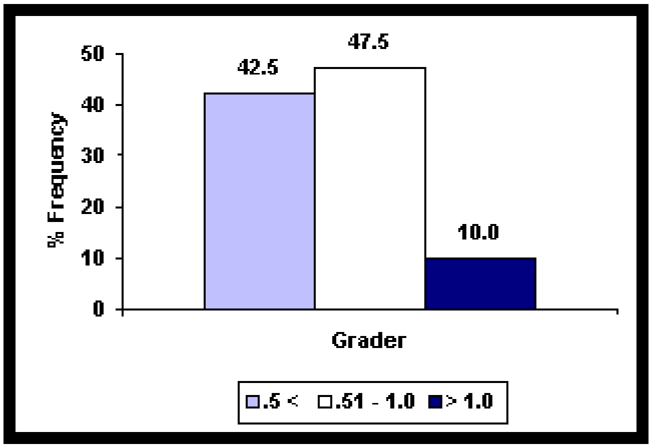

Figure 2. Frequency distribution of absolute differences between VIA color score and expert grader color scores.

Table 1. Characterization of ribeye steaks.

Trait	Mean	Min.	Max.	SD	t-tests[a]
Marbling trait					
Lipid (L), %	6.23	4.8	8.3	.86	--
Expert grader (E), %	5.92	4.0	7.4	.77	LE
VIA marbling (V), %	5.76	4.4	7.0	.72	LV
Color score	4.53	3.3	8.8	1.25	--
VIA color score	3.93	2.6	7.2	.94	--

[a]LE (P<.05); LV (P<.05).