EFFECTIVENESS OF THE COMPUTER VISION SYSTEM EQUIPPED WITH A BEEFCAM MODULE TO CLASSIFY URUGUAYAN BEEF CARCASSES INTO DIFFERENT MARKETING GROUPS

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Background

Consumers are willing to pay a premium for beef that is known to be tender (Shackelford et al., 2001). Currently, there is considerable variation in the maturity of cattle produced by the Uruguayan beef industry that contributes to inconsistency in tenderness and lean color of beef. Research conducted by Hodgson et al. (1992) and Hilton et al. (1998) suggested that mature cow carcasses can be sorted into groups that differ in palatability using measurements of fat color and marbling. Wulf and Page (2000) demonstrated that measurements of longissimus muscle color are related to the tenderness of beef from young carcasses. Vote et al. (2003) reported that online video image analysis measurements of marbling, longissimus muscle area, lean and fat color obtained from a Computer Vision System equipped with a BeefCam module (CVS BeefCam) were useful in predicting the Warner-Bratzler shear force (WBSF) values of longissimus steaks.

Objectives

This study was conducted to determine if measurements obtained from a CVS BeefCam could be used to sort Uruguayan beef carcasses into different marketing groups to reduce variation in quality.

Methods

Over a 5-week period at a commercial Uruguayan packing plant, beef carcasses (n = 345) were selected (after the hot carcass scale) by Colorado State University (CSU) personnel to represent the variety of carcasses produced in Uruguay with respect to maturity, hot carcass weight, fat thickness, and muscling, while maintaining a balance between male and female carcasses (n = 172 and 173, respectively). Carcasses were chilled overnight for 15 to 23 hours, except for carcasses selected on Fridays (weeks three and four) which were chilled for 63 to 71 hours, and on Saturdays (weeks one and two) which were chilled for 39 to 47 hours. After chilling, carcasses were transferred to a holding rail where one side was randomly selected and ribbed between the 10th and 11th ribs. Bone dust created during ribbing was removed from the exposed surface of the longissimus muscle and images were obtained using a CVS BeefCam as soon as possible after ribbing and again approximately 50 minutes after ribbing. Dark cutting carcasses (one-third grade discount) were identified by visual appraisal and USDA quality grade factors were assigned by CSU personnel. A 2.54-cm thick steak of the longissimus muscle was removed from each carcass, aged until 14 days postmortem, and then frozen and stored for subsequent analysis. Frozen steaks were thawed for 24 hours at 4°C before being cooked in a water bath (80°C) until they reached an internal temperature of 70°C determined by use of a thermocouple (type E Barnnat 115). Steaks were then chilled for 3 to 4 hours at 4°C before removing 6 cores (1.27 cm) parallel to the muscle fiber orientation. A single, peak shear force measurement was obtained for each core using a WBSF machine. Individual peak WBSF values were averaged for cores within a steak sample to assign a mean peak WBSF value to each steak.

Statistical Approach: Descriptive statistics were computed for USDA quality grade factors, CVS BeefCam output variables, and WBSF values using SAS. An initial correlation analysis using SAS was performed to compare the relationship between CVS BeefCam output variables for lean color and WBSF values for carcasses sampled at both image times (shortly after ribbing and approximately 50 minutes after ribbing). A second correlation analysis using SAS was conducted between CVS BeefCam output variables and WBSF values using all carcasses sampled and excluding carcasses that were considered to be dark cutters. For an objective measurement system to be commercially applicable, it must be able to classify all types of carcasses that are produced, thus the following analysis was used to develop a carcass sorting system using CVS BeefCam measurements to classify carcasses into different marketing groups. First, the tree model of S-PLUS (1998) was used to develop a CVS BeefCam lean color threshold to classify carcasses as dark cutters because they are discriminated against at retail by consumers and often are not eligible for export because of their high pH values. Use of lean color measurements shortly after ribbing did not prove to be useful for identifying carcasses as dark cutters. However, using lean color measurements obtained following an approximate bloom time of 50 minutes, carcasses with a lean L*, lean a*, and lean b* product value of less than 8385 were classified as dark cutters. Forty carcasses were classified as dark cutters using this CVS BeefCam lean color threshold and were excluded from the remaining analyses. The following WBSF prediction equation: predicted WBSF value = 12.801 – 0.519(CVS BeefCam marbling) – 0.270(lean a*) + 0.115(fat b*) + 2.392(adjusted LMA) published by Vote et al. (2003), was applied to the carcasses not classified as dark cutters by CVS BeefCam. Carcasses were then segregated into four groups based upon their predicted WBSF using the Vote et al. (2003) equation. Actual WBSF value, LMA, lean L*, lean a*, lean b*, fat L*, fat a*, fat b* and CVS BeefCam marbling means for the five total groups were compared using ANOVA and separated using Tukey's HSD (SAS).

Results and Discussion

Descriptive statistics for carcass traits are presented in Table 1. Coefficient of variation values indicated that the sample was very diverse in both lean and skeletal maturity, as well as in WBSF values. Although not indicated in tabular form, a relatively high proportion of carcasses sampled were considered to be dark cutters (17.4%). Correlation coefficients between the lean color output variables and WBSF values were similar regardless of carcass bloom time (data not presented in tabular form). When the dark cutting carcasses were excluded and the correlation analysis was repeated, larger correlation coefficients between lean color output variables and WBSF values were observed for the images collected approximately 50 minutes after ribbing, whereas correlation coefficients between fat color, marbling, and adjusted LMA output variables and WBSF remained similar in magnitude (Table 2). The CVS BeefCam lean color threshold value correctly identified 37 of the 60 dark cutting carcasses, while only incorrectly classifying 3 normal lean color carcasses as dark cutters. Use of the equation developed by Vote et al. (2003) explained 17% of the observed variation in WBSF values and results using that equation to sort carcasses into groups are presented in Table 3. Group 4 had the highest WBSF values among the groups, whereas group 1 was much more consistent in WBSF values than other groups as indicated by the smaller standard error value. Also, group 4 and the dark cutter group of carcasses had lower lean L* and lean a* values than the rest of the groups.

Table 1. Descriptive statistics of USDA quality grade factors, CVS BeefCam output variables, and WBSF values (n = 345)[a]

Trait	Mean	SD	Min	Max	CV, %
Skeletal maturity[b]	159	146.4	30	500	92.1
Lean maturity[bc]	139	96.0	20	430	69.2
Marbling score[d]	330	73.6	160	770	22.3
Hot carcass weight, kg	225.1	39.6	149.0	374.2	17.6
LMA, cm^2	50.9	8.4	30.2	87.8	16.5
Lean L*	33.8	3.0	25.7	43.1	8.7
Lean a*	27.9	3.9	12.6	34.1	14.0
Lean b*	12.9	1.5	7.9	17.2	11.6
Fat L*	71.3	4.5	50.6	79.7	6.4
Fat a*	7.7	2.1	1.9	22.1	27.1
Fat b*	16.8	3.8	6.4	27.9	22.6
WBSF, kg	3.7	1.3	1.4	9.5	34.6

[a]Measured at the $10^{th}/11^{th}$ rib interface.
[b]Maturity: 0 = A^{00}, 100 = B^{00}, 200 = C^{00}, 300 = D^{00}, 400 = E^{00}.
[c]Lean maturity not evaluated on dark cutting carcasses (n = 60).
[d]Marbling score: 100 = Practically devoid^{00}, 200 = Traces^{00}, etc.

Table 2. Correlation coefficients between WBSF and output variables from CVS BeefCam[a]

CVS BeefCam output variable	WBSF, kg	
	All carcasses	Dark cutters excluded[b]
Adjusted LMA (cm^2/kg of hot carcass weight)	0.08	0.06
Marbling[c]	-0.14*	-0.10
Lean L*	-0.12*	-0.28*
Lean a*	-0.11*	-0.40*
Lean b*	-0.11*	-0.24*
Fat L*	-0.15*	-0.20*
Fat a*	0.05	0.08
Fat b*	0.05	0.04

[a]Values obtained from images collected approximately 50 minutes after ribbing.
[b]Carcasses not classified as dark cutters (n = 285).
*Correlation differs from zero (P < 0.05).

Table 3. Results of classifying carcasses into five groups using measurements from a CVS BeefCam[a]

Trait	Group mean (SE)										
	1		2		3		4		Dark cutters		P
n	77	-	76	-	76	-	76	-	40	-	
LMA, cm^2	51.1	(1.09)	50.4	(0.91)	51.1	(0.96)	51.0	(0.87)	50.6	(1.39)	0.9821
Lean L*	36.0^{b}	(0.27)	35.1^{b}	(0.23)	34.3^{c}	(0.25)	32.6^{d}	(0.16)	28.8^{e}	(0.26)	<0.0001
Lean a*	30.7^{b}	(0.20)	29.8^{c}	(0.20)	28.8^{d}	(0.20)	26.7^{e}	(0.20)	19.5^{f}	(0.55)	<0.0001
Lean b*	13.5^{b}	(0.14)	13.4^{bc}	(0.14)	13.4^{bc}	(0.15)	12.9^{c}	(0.11)	10.5^{d}	(0.19)	<0.0001
Fat L*	72.7^{b}	(0.49)	72.7^{b}	(0.39)	71.5^{bc}	(0.40)	70.1^{cd}	(0.61)	68.2^{d}	(0.81)	<0.0001
Fat a*	7.9	(0.19)	7.6	(0.26)	7.7	(0.21)	7.4	(0.22)	8.2	(0.48)	0.3672
Fat b*	16.0^{cd}	(0.42)	16.5^{cd}	(0.41)	17.1^{bc}	(0.43)	18.3^{b}	(0.45)	15.1^{d}	(0.46)	<0.0001
CVS BeefCam marbling	1.9^{b}	(0.15)	1.3^{c}	(0.10)	1.1^{c}	(0.09)	1.0^{c}	(0.07)	2.0^{b}	(0.16)	<0.0001
WBSF, kg	3.2^{d}	(0.08)	3.5^{cd}	(0.11)	3.8^{c}	(0.15)	4.4^{b}	(0.16)	3.6^{cd}	(0.28)	<0.0001

[a]First, carcasses with a lean L*, lean a*, and lean b* product value less than 8385 were classified as dark cutters. Second, predicted WBSF values were obtained using the equation presented by Vote et al. (2003). Group 1 represents the predicted "most tender" 25% of carcasses, group 2 represents the second predicted "most tender" 25% of carcasses, group 3 represents the third predicted "most tender" 25% of carcasses, and group 4 represents the predicted "toughest" 25% of carcasses.
[b, c, d, e, f]Means within a row that do not have a common superscript letter differ (P < 0.05).

Conclusions

The results of this study indicate that video image analysis measurements obtained from a CVS BeefCam used with a previously developed regression equation could be used to sort Uruguayan beef carcasses into marketing groups that differ in the tenderness and color of their steaks. Postmortem processes known to improve tenderness could be applied to selected groups and then carcasses could be more efficiently directed to the optimum markets to satisfy consumer demand.

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