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Using Lean Color and Marbling Score to Sort Beef Carcasses into Tenderness Groups

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Muscle color measurements, either alone, or in conjunction with marbling scores, were no more effective than marbling alone to sort carcasses into tenderness groups.

Summary

Beef carcasses (n=290) were used to determine the effectiveness of color (L - lightness; a* - redness; b* - yellowness) measured at least 90 minutes after ribbing and marbling called by USDA graders to sort beef carcasses into one of three tenderness groups. Equations using any combination of marbling and color were no more effective in sorting beef carcasses into tenderness groups than marbling alone. None of the tough carcasses were correctly classified. Adding color to marbling does not improve effectiveness of sorting beef carcasses into tenderness groups.*

Introduction

Consumers rate tenderness as an important palatability trait affecting overall satisfaction of beef. Several researchers have correlated measurement of muscle color with meat tenderness, and have used color to sort beef carcasses into palatability groups.

This research was conducted to create a sorting system based on objective color measurements and marbling to sort beef carcasses into tenderness groups in a commercial slaughter facility in Nebraska.

Procedure

This study used 290 beef strip loins selected from three quality grades (Select, low Choice, and upper 2/3 Choice). University of Nebraska personnel collected beef strip loins at a commercial slaughter facility. A selection grid involving 90-minute L* color measurements made on the 12th rib surface of beef carcasses with a Hunter Miniscan™ Plus XE colorimeter (1-inch port) and quality grade (marbling score, called by a USDA grader) was used to select loins. Upper 2/3 Choice and low Choice had 2 selection cells with L*>44 and L*<44. The Select quality grade was divided into high (marbling scores Slight[50]) and low Select (marbling scores< Slight[50]) and involved carcasses with L*<44, >47, and between 44 and 47.

Color traits measured were L* (lightness), a* (redness) and b* (yellowness), which are points used to objectively define any color in a three-dimensional color space. The colorimeter was calibrated against a white plate using illuminant A and 10° standard observer.

The beef strip loins were labeled, vacuum packaged, boxed, and then shipped to the University of Nebraska, where they were allowed to age a total of nine days post-mortem at 34°F. After aging, the strip loins were frozen (-14.8°F) for further storage. The frozen loins were allowed to temper for a total of 24 hours at 34°F before being cut into 1-inch thick strip steaks on a band saw. The first steak from each loin was wrapped and frozen until it was analyzed for tenderness (Warner-Bratzler shear force).

Steaks were thawed at 34°F for 24 hours and cooked to an internal temperature of 104°F, turned, and cooked to a final internal temperature of 158°F. Steaks were cooled for two hours at 64°F before removal of eight cores (1/2 in. diameter) parallel to the longitudinal axis of the muscle fibers. An average of the peak shear force of 8 sheared cores was calculated for each strip.

Tenderness was predicted using equations that contained a*, b*, and marbling score, alone or in combination. Tenderness groups were based on shear force: tender (<8.5 lb), intermediate (8.5-10.0 lb), and tough (>10.0 lb).

Results

Marbling score was the best single-trait predictor of beef tenderness, explaining 12% of the variation in tenderness (Table 1). Color measurements (L*, a*, and b*) by themselves explained little (.6%, 2.9%, and 1.5%, respectively) of the variation in shear force values. Taken together, marbling, a*, and b* were able to explain 13.7% of the variation in beef tenderness. With the most complex model, which contained significant interactions of color measurements (a* and b*) and marbling, just 16.6% of the variability in beef tenderness was explained:

$$\text{Shear Force} = 13.79-.31(b^*)+.03\,(a^*)(b^*)-.03(a^*)^2-.18(\text{marbling})\,(a^*)+.01\,(\text{marbling})(a^*)^2$$

where marbling was coded as 4.00=Slight[00] and 5.00=Small[00].

Table 1. The relationship of muscle color and marbling score, alone and in conjunction, to shear force value.

Trait	Coefficient of Determination $R^2 \times 100$
L*	0.5
a*	2.9
b*	1.5
Marbling Score	12.0
Marbling and a*	13.1
Marbling and b*	12.3
Marbling, a*, and b*	13.7
Complete Model[a]	16.6

[a]Complete model includes all possible interactions.

Muscle color measurements, marbling, and a combination of muscle color and marbling were used to predict beef tenderness categories (Tables 2, 3, and 4). Carcasses were sorted into tender (<8.5 lb), intermediate (8.5-10.0 lb), and tough (>10.0 lb) groups. Applying this classification method to actual Warner-Bratzler shear force values, 63.1% of the carcasses (183 of 290) were tender, 22.5% (65 of 290) were intermediate in tenderness, and 14.5% (42 of 290) were tough. When carcasses were classified into the predicted tenderness categories using a* and b* measurements (Table 2), 159 of 183 were correctly identified as tender, 14 of 65 were correctly identified as intermediate, and none of the 42 tough carcasses were correctly identified. Of the 238 carcasses predicted to be tender, 51 were actually intermediate in tenderness, and 28 were tough. Said

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Table 2. Actual versus predicted tenderness of beef carcasses utilizing muscle color measurements (a* and b*).

		Actual Shear Force Category			
		Tender	Intermediate	Tough	
Predicted Shear Force Category[a]		(<8.5 lb)	(8.5-10.0 lb)	(>10.0 lb)	Total[b]
Tender	Number	159	51	28	238
	% of those predicted tender	66.8	21.4	11.8	
	% of total correctly predicted	54.8			
Intermediate	Number	23	14	14	51
	% of those predicted intermediate	45.1	27.5	27.5	
	% of total correctly predicted		4.8		
Tough	Number	1	0	0	1
	% of those predicted tough	100	0	0	
	% of total correctly predicted			0	
	Total[c]	183	65	42	290
	% of	63.1	22.4	14.5	

[a]Predicted tenderness model (Shear force, lb = 13.41 - .33 (a*) + .18 (b*)).
[b]Total number of predicted carcasses in each classification.
[c]Total number and percent of total of actual carcasses in each classification.

Table 3. Actual versus predicted tenderness of beef carcasses utilizing marbling scores.

		Actual Shear Force Category			
		Tender	Intermediate	Tough	
Predicted Shear Force Category[a]		(<8.5 lb)	(8.5-10.0 lb)	(>10.0 lb)	Total[b]
Tender	Number	145	41	24	210
	% of those predicted tender	69.0	19.5	11.4	
	% of total correctly predicted	50.0			
Intermediate	Number	38	24	18	80
	% of those predicted intermediate	47.5	30.0	22.5	
	% of total correctly predicted		8.3		
Tough	Number	0	0	0	0
	% of those predicted tough	0	0	0	
	% of total correctly predicted			0	
	Total[c]	183	65	42	290
	% of total	63.1	22.4	14.5	

[a]Predicted tenderness model (Shear force, lb = 12.42 - .75 (marbling)), where Slight 0 = 400.
[b]Total number of predicted carcasses in each classification.
[c]Total number and percent of total of actual carcasses in each classification.

Table 4. Actual versus predicted tenderness of beef carcasses utilizing marbling scores and color measurements.

		Actual Shear Force Category			
		Tender	Intermediate	Tough	
Predicted Shear Force Category[a]		(<8.5 lb)	(8.5-10.0 lb)	(>10.0 lb)	Total[b]
Tender	Number	138	35	18	191
	% of those predicted tender	72.3	18.3	9.4	
	% of total correctly predicted	47.6			
Intermediate	Number	45	30	24	99
	% of those predicted intermediate	45.5	30.3	24.2	
	% of total correctly predicted		10.3		
Tough	Number	0	0	0	0
	% of those predicted tough	0	0	0	
	% of total correctly predicted			0	
	Total[c]	183	65	42	290
	% of total	63.1	22.4	14.5	

[a]Predicted tenderness model (Shear force, lb = 15.00 - .70 (marbling) - .22 (a*) + .13 (b*)), where Slight 0 = 400.
[b]Total number of predicted carcasses in each classification.
[c]Total number and percent of total of actual carcasses in each classification.

another way, just 2/3 of the carcasses predicted to be tender actually were tender. Clearly, the use of color alone is ineffective in sorting beef carcasses into tenderness categories.

When marbling was used to predict tenderness categories, 145 tender, 24 intermediate, and no tough carcasses were correctly identified (Table 3). For those 210 carcasses predicted to be tender, just 69% actually were tender; 41 were intermediate and 24 were tough, indicating marbling alone was not a good predictor of shear force in the population of carcasses studied in this research.

Combining marbling and color measurements did not substantially improve classification of carcasses into tenderness categories, in that 138 of 290 tender carcasses, 30 of 65 intermediate, and no tough carcasses were correctly sorted (Table 3). Of the 191 predicted to be in the tender category, 72% actually were tender; 35 were intermediate in tenderness and 18 were tough. It appears sorting carcasses on the basis of color and marbling is generally unsuccessful.

These data suggest color was not effective at finding tough carcasses, as tough carcasses were never predicted to be tough. At best, a small percentage of tough carcasses were predicted to be intermediate in toughness — clearly not an acceptable sorting tool.

In this experiment, beef carcasses were all from one slaughter facility in Nebraska, and were very similar in carcass traits, making it difficult to create a system to sort beef carcasses into tenderness groups. This would suggest that individual slaughter facilities which handle carcasses of similar traits may not benefit from a carcass sorting system of this nature.

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