

Can the relationship between beef color and tenderness be explained by myoglobin regulating calpain-1? (#277)

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Introduction

Meat color and tenderness are two of the most important traits for overall consumer perception of meat quality [1, 2]. Consumers are willing to pay a premium for beef products that are guaranteed tender [3, 4]. Tenderization that occurs during aging is attributed to the calpain system, an endogenous protease system responsible for proteolysis of myofibrillar proteins [5, 6]. Previous reports indicate that calpain-1 is the primary protease responsible for tenderization of beef during aging [5, 6]. Myoglobin is the main sarcoplasmic protein responsible for meat color. Previous research revealed a relationship between meat color and beef tenderness [7, 8, 9] and indicated that myoglobin can inhibit calpain-1 in solution [10, 11]. The objective of this study was to determine the extent to which myoglobin and beef color are associated with calpain activity and beef tenderness.

Methods

Longissimus lumborum samples from the left side of Holstein beef carcasses (n = 21) were collected immediately post exsanguination on the processing floor for 0 h analyses of calpain-1, myoglobin concentration, and metmyoglobin reducing activity (MRA). Muscle temperature and pH were measured at 0, 24, and 48 h postmortem. USDA yield and quality grades were determined 48 h postmortem, immediately after grading, steaks (n = 6) were removed from the right side of each carcass (n = 21) for analyses at 48 and 336 h. Steaks assigned to 336 h analysis were vacuum packaged and aged. At 48 and 336 h objective color (L*, a*, and b* values) via a HunterLab MiniScan, MRA, myoglobin concentration, calpain-1, slice shear force (SSF), and Warner-Bratzler shear force (WBSF) were measured. Calpain-1 concentrations and autolysis were determined via Western blot. Western blots were analyzed using Image Lab analysis software (Image Lab Version 5.2.1). Means and correlations were generated using SAS (SAS Version 9.4).

Results

Carcasses in this study had a mean USDA yield grade of 1.6 with an adjusted fat thickness of 0.13 cm and mean USDA quality grade of Select³⁴. Declining mean values obtained for pH and temperature, over time, indicate normal development of rigor mortis (Table 1). Decreases in shear force values indicate a normal response to aging over time which has been attributed to calpain-1 activity. Objective surface color measurements (Table 1) were within normal range for beef at 48 and 336 h post mortem. After protein load normalization to a reference

protein, myosin, calpain-1 relative abundancies decreased ($P < 0.05$) over time, indicating autolysis, with mean values of 1.23, 0.87, and 0.79 for 0, 48, and 336 h, respectively (Figure 1). Myoglobin content decreased ($P < 0.05$) between 0 and 48 h, whereas MRA increased ($P < 0.05$). Metmyoglobin reducing activity at 48 h was positively correlated to WBSF at 48 h and negatively correlated to calpain-1 concentration at 0 h ($P < 0.05$; Table 2). Color measurements of L* and b* at 48 h were moderately correlated with WBSF at 336 h ($P < 0.05$; Table 2). The b* measurement at 336 h showed a moderate relationship to calpain-1 concentration at 0 h ($P < 0.05$; Table 2). Table 1. General Meat Characteristics (Mean \pm SE) from Holstein Beef *Longissimuslumborum* steaks (n = 21)

	0 h	24 h	48 h	336 h	
pH	6.4 \pm 0.05	5.8 \pm 0.03	5.6 \pm 0.02	-	
Temperature (°C)	35.8 \pm 0.35	1.7 \pm 0.08	1.1 \pm 0.13	-	
L*	-	-	36.7 \pm 0.35	38.1 \pm 0.70	
a*	-	-	16.2 \pm 0.19	13.4 \pm 0.56	
b*	-	-	12.4 \pm 0.23	12.9 \pm 0.52	
Myoglobin (mg/kg)	4.7 \pm 0.09	-	3.8 \pm 0.09	3.7 \pm 0.10	
MRA	22.0 \pm 0.09	-	42.6 \pm 2.49	42.2 \pm 0.10	
WBSF (N)	-	-	73.2 \pm 5.00	48.8 \pm 1.33	
SSF (N)	-	-	348.2 \pm 19.68	260.5 \pm 13.73	
	WBSF 48 h	WBSF 336 h	SSF 48 h	Calpain-1 0 h	Calpain-1 48 h
Myoglobin 0 h			0.386**		
Myoglobin 48 h				-0.476*	
MRA 48 h	0.381**				
MRA 336 h	0.457*		0.372**		

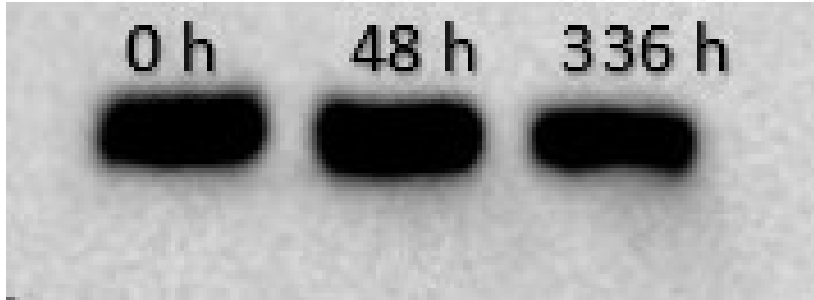
	0 h	24 h	48 h	336 h	
pH	6.4 \pm 0.05	5.8 \pm 0.03	5.6 \pm 0.02	-	
L* 48 h		0.469*			
b* 48 h		0.469*			
b* 336 h				0.472*	0.397**

Table 2. Correlations between selected color and tenderness measurements (n = 21)

Notes

Conclusion

General meat characteristics revealed normal rigor mortis, color, and aging development in these samples. Moderate correlations between beef color and tenderness measurements at 48 and 336 h were discovered indicating that myoglobin may impact calpain-1 in vivo.



Figure

1. Representative Calpain-1 Western Blot

Notes