Relationships among various glucose metabolism traits, fresh beef quality attributes, and cooked beef tenderness

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Abstract

Carcasses (n = 14) from progeny of two Charolais sires were separated into two equal sized groups based on longissimus muscle (LD) b* colorimeter values (highest b* values = HIGHB; lowest b* values = LOWB) to explore relationships among various glucose metabolism traits, fresh beef quality attributes, and cooked beef tenderness. Various live animal and carcass measures were compared between the two groups. Live animal measurements included hormone levels, serum chemistry profiles, chute scores, and live weight data; at harvest, hormone levels and serum chemistry profiles were determined. Temperature and pH were measured in the LD, psoas major (PM), semimembranosus (SM), semitendinosus (ST), and triceps brachii (TB) at 0 h, 45 min, 3 h, 6 h, 12 h, 24 h, and 48 h postmortem. At 48 h postmortem, all routine yield and quality grade data were obtained, colorimeter readings (L*, a*, b*) were taken on exposed LD, PM, SM, ST, and TB muscles, and selected muscles (LD, SM, TB) were sampled for sarcomere length and glycolytic potential determination. Shear force was measured on LD samples at 1, 2, 3, 4, 5, 6, 7, 10, 14, 21, and 35 d postmortem, on SM samples at 2, 4, 7, 10, 14, 21, and 35 d postmortem, and on PM, ST, and TB samples at 2, 7, 14, and 35 d postmortem. Purge loss and cooking loss were determined on various muscles. Serum assays during the feedlot phase revealed that HIGHB animals had higher ($P < 0.05$) creatinine and sodium levels and lower ($P < 0.05$) glucagon levels than LOWB animals. Circulating levels of chloride, creatinine, and sodium were higher ($P < 0.05$) and magnesium, glucagon, and cortisol were lower ($P < 0.05$) in the HIGHB group than the LOWB group at slaughter. Animals in the HIGHB group were heavier ($P < 0.05$) from weaning to slaughter than animals in the LOWB group, but average daily gains in the feedlot were similar ($P > 0.05$) between the two groups. Correspondingly, HIGHB carcasses were significantly heavier and had larger ($P < 0.05$) ribeye areas than LOWB carcasses. Muscle pH was lower ($P < 0.05$) in HIGHB carcasses for LD at 0 h, PM at 48 h, SM at 48 h, ST at 3 h, and TB at 24 and 48 h and higher ($P < 0.05$) for PM at 12 h than in LOWB carcasses. Temperature measurements were higher ($P < 0.05$) for HIGHB than LOWB at 12 h postmortem in the LD and SM. All colorimeter readings (L*, a*, b*) of LD and TB muscles were higher ($P < 0.05$) for HIGHB than LOWB; L* and b* readings of SM and ST muscles were higher ($P < 0.05$) for HIGHB than LOWB. Longissimus muscle sections from HIGHB carcasses had greater ($P < 0.05$) purge loss than LOWB LD, and cooking losses were greater ($P < 0.05$) at several aging times for HIGHB muscles compared to LOWB muscles. Carcasses from the HIGHB group had lower ($P < 0.05$) shear force values for LD at 2, 6, 7, 10, 14, and 35 d postmortem, for SM at 7 and 10 d postmortem, and for ST at 2 d postmortem than LOWB carcasses. All other live animal and carcass measures were not different ($P > 0.05$) between HIGHB and LOWB groups. Our findings suggest that there seems to be some link between circulating amounts of blood constituents in live animals and muscle color, and that higher LD b* values are associated with greater pH decline, lower ultimate pH, lower water-holding capacity, and improved beef tenderness.

Introduction

Postmortem muscle color is directly associated with ante-mortem muscle glycogen content, postmortem muscle pH decline, and ultimate muscle pH. The pH at specific times during the conversion of muscle to meat, as well as the ultimate pH of meat, affects many meat quality factors, including tenderness. Also, other ante-mortem and postmortem factors such as stress, sarcomere length, and purge loss may play a role in glucose metabolism, fresh beef quality, and beef tenderness.

Objective

The objective of this study was to explore relationships among various glucose metabolism traits, fresh beef quality attributes, and cooked beef tenderness of two different groups of carcasses separated based on longissimus muscle b* colorimeter values (highest b* values = HIGHB; lowest b* values = LOWB).

Materials & Methods

2 Charolais sires x Angus-crossbred cows

↓

14 progeny

↓

Weaned

↓

Fed a growing diet

↓

SDSU Beef Feedlot Research Unit
(Finishing period ranged from 102 to 136 d)

↓

Harvested in three groups

- Carcasses (n = 14) were separated into two equal sized groups based on longissimus (LD) b* colorimeter values (highest b* values = HIGHB; lowest b* values = LOWB)
- Live animal measurements included hormone levels and serum chemistry profiles (measured two times in the feedlot and at harvest), chute scores (measured at weaning and four times in the feedlot), and live weight data.
- Temperature and pH measured in the LD, psoas major (PM), semimembranosus (SM), semitendinosus (ST), and triceps brachii (TB) at 0 h, 45 min, 3 h, 6 h, 12 h, 24 h, and 48 h postmortem.
- All routine USDA yield and quality grade data collected.
- Colorimeter readings (L*, a*, b*) were taken on LD, PM, SM, ST, and TB muscles, and selected muscles (LD, SM, TB) were sampled for sarcomere length and glycolytic potential determination.
- Warner-Bratzler shear force measured on LD samples at 1, 2, 3, 4, 5, 6, 7, 10, 14, 21, and 35 d postmortem, on SM samples at 2, 4, 7, 10, 14, 21, and 35 d postmortem, and on PM, ST, and TB samples at 2, 7, 14, and 35 d postmortem.
- Purge loss and cooking loss determined for various muscles.
- All live animal and carcass measures were compared between LOWB and HIGHB groups using one-way ANOVA (SAS Inst. Inc., Cary, NC).

Results and Discussion

Table 1. Means for hormones and serum chemistry profiles at slaughter

Trait	Group LOWB	Group HIGHB	Std. error	*P* value
Cortisol, µg/dl	**8.57**	**6.57**	**0.48**	**0.01**
Epinephrine, pg/ml	548.14	809.43	326.82	0.58
Norepinephrine, pg/ml	685.71	794.71	368.41	0.84
Insulin, µU/ml	29.29	31.86	4.99	0.72
Glucagon, pg/ml	**252.57**	**138.86**	**28.39**	**0.02**
Albumin, g/dl	4.00	3.80	0.09	0.15
Alkaline Phos., IU/L	72.71	86.29	5.01	0.08
Amylase, IU/L	12.43	14.57	1.09	0.19
AST=SGOT, IU/L	81.29	76.71	6.94	0.65
Bilirubin, mg/dl	0.40	0.30	0.06	0.23
BUN, mg/dl	14.43	16.71	1.68	0.36
Calcium, mg/dl	8.41	8.47	0.15	0.79
Chloride, Mmol,/L	**102.71**	**97.14**	**1.21**	**<0.01**
CPK, IU/L	1084.57	788.71	339.55	0.55
Creatinine, mg/dl	**1.51**	**1.79**	**0.06**	**<0.01**
GGTP, IU/L	16.57	14.29	1.33	0.25
Globulin, g/dl	3.07	3.14	0.28	0.86
Glucose, mg/dl	122.14	114.43	5.38	0.33
Magnesium, mEq/L	**2.24**	**1.71**	**0.16**	**0.04**
Phosphorus, mg/dl	7.63	7.60	0.44	0.96
Potassium, mEq/L	4.58	4.96	0.21	0.21
Sodium, mEq/L	**142.41**	**149.80**	**1.50**	**<0.01**
Total protein, g/dl	7.09	6.97	0.31	0.80

- Serum assays during the feedlot phase (not shown in tabular form) revealed that HIGHB animals had higher ($P < 0.05$) creatinine and sodium levels and lower ($P < 0.05$) glucagon levels than LOWB animals.
- Circulating levels of chloride, creatinine, and sodium were higher ($P < 0.05$) and magnesium, glucagon, and cortisol were lower ($P < 0.05$) in the HIGHB group than the LOWB group at slaughter.

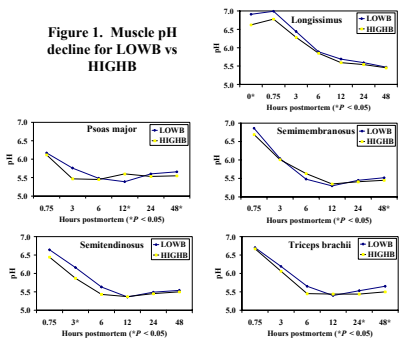
Table 2. Means for live animal traits

Trait	Group LOWB	Group HIGHB	Std. error	*P* value
Gestation length, d	281.71	277.57	2.36	0.24
Weaning wt, kg	**215.30**	**240.35**	**6.55**	**0.02**
Slaughter wt, kg	**421.61**	**470.86**	**11.79**	**0.01**
Feedlot ADG, kg	1.13	1.16	0.08	0.78
Avg. chute score[a]	2.26	2.87	0.26	0.12

[a]Chute score (1-5): lower number indicates calmer disposition.

- HIGHB group animals were heavier ($P < 0.05$) from weaning to slaughter than animals in the LOWB group, but ADG in the feedlot was similar ($P > 0.05$) between the two groups.

Figure 1. Muscle pH decline for LOWB vs HIGHB



- Muscle pH was lower ($P < 0.05$) in HIGHB carcasses for LD at 0 h, PM at 48 h, SM at 48 h, ST at 3 h, and TB at 24 and 48 h and higher ($P < 0.05$) for PM at 12 h than in LOWB carcasses.
- Temperature measurements (not shown in tabular form) were higher ($P < 0.05$) for HIGHB than LOWB at 12 h postmortem in the LD and SM.

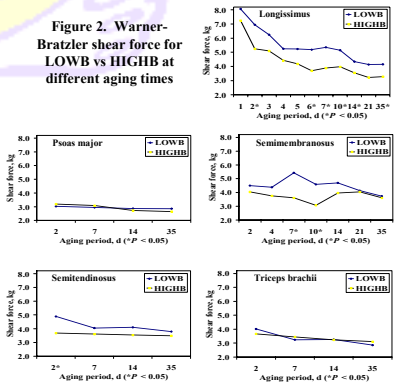
Table 3. Means for USDA yield and quality grade traits, b*, purge loss, sarcomere length, and glycolytic potential

Trait	Group LOWB	Group HIGHB	Std. error	*P* value
Dressing percent	65.99	65.13	0.73	0.42
Hot carcass wt, kg	**278.01**	**306.55**	**7.68**	**0.02**
Fat thickness, cm	1.09	0.94	0.02	0.30
Ribeye area, cm²	69.21	75.92	2.40	0.07
KPH, %	4.19	3.85	0.31	0.45
Yield grade	3.31	3.00	0.18	0.27
Marbling score[a]	442.86	407.14	26.34	0.36
Lean maturity[b]	188.57	154.29	12.75	0.08
Skeletal maturity[b]	144.29	142.86	3.64	0.79
Overall maturity[b]	**164.29**	**147.14**	**5.47**	**0.05**
b*[c]				
Longissimus	**10.45**	**12.39**	**0.31**	**<0.01**
Psoas major	10.53	10.61	0.30	0.86
Semimembranosus	**13.43**	**14.60**	**0.33**	**0.03**
Semitendinosus	**11.82**	**12.77**	**0.30**	**0.04**
Triceps brachii	**8.50**	**9.80**	**0.21**	**<0.01**
Purge loss, %				
Longissimus	**0.98**	**1.35**	**0.09**	**0.01**
Gluteus medius	1.57	1.88	0.23	0.35
Semimembranosus	1.01	1.35	0.27	0.38
Sarcomere length, µm				
Longissimus	1.80	1.91	0.05	0.11
Semimembranosus	1.70	1.82	0.06	0.14
Triceps brachii	2.15	2.32	0.10	0.25
GP[d], µmoles/g				
Longissimus	128.49	135.21	6.45	0.48
Semimembranosus	147.89	154.73	8.23	0.57
Triceps brachii	122.26	136.81	6.63	0.15

[a]300 = Slight[00], 400 = Small[00], etc.
[b]100 = A[00], 200 = B[00], etc.
[c]b*: -60 = blue, 60 = yellow.
[d]Glycolytic potential.

- HIGHB carcasses were significantly heavier ($P < 0.05$) than LOWB carcasses.
- All colorimeter readings (L*, a*, b*) of LD and TB muscles were higher ($P < 0.05$) for HIGHB than LOWB; L* and b* readings of SM and ST muscles were higher ($P < 0.05$) for HIGHB than LOWB (L* and a* not shown in tabular form).
- LD from HIGHB carcasses had greater ($P < 0.05$) purge loss than LOWB LD, and cooking losses (not shown in tabular form) were greater ($P < 0.05$) at several aging times for HIGHB compared to LOWB muscles.

Figure 2. Warner-Bratzler shear force for LOWB vs HIGHB at different aging times



- Carcasses from the HIGHB group had lower ($P < 0.05$) shear force values for LD at 2, 6, 7, 10, 14, and 35 d postmortem, for SM at 7 and 10 d postmortem, and for ST at 2 d postmortem than LOWB carcasses.

Implications

Our findings suggest there is some link between circulating amounts of blood constituents in live animals and muscle color, and that higher LD b* values are associated with greater pH decline, lower ultimate pH, lower water-holding capacity, and improved beef tenderness.