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COLOR STABILITY OF STEAKS FROM CARCASSES VASCULARLY INFUSED IMMEDIATELY AFTER EXSANGUINATION

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Summary

Hereford × Angus carcasses were infused with a solution of either sugar/phosphate or calcium chloride immediately after exsanguination to determine effects on color stability during retail display. A calcium chloride solution darkened the cuts and reduced color stability. A sugar/phosphate blend made steaks appear lighter red (more desirable), and their color stability was equal to that of the noninfused control.

(Key Words: Beef, Infusion, Display, Color Stability.)

Introduction

Vascular infusion of carcasses immediately after bleeding can increase yields, cause faster chilling, and improve meat tenderness. Infusion could affect meat color, because pumping aqueous solutions through the vascular system may change pH decline and dilute or remove muscle pigments and create a "lighter" than normal appearance. Conversely, accelerated chilling by chilled infusion solutions may improve color stability. Our objective was to determine the effects of vascular infusion of two different solutions immediately after bleeding on the initial color, uniformity of muscle color, and display color stability of steaks.

Experimental Procedures

Thirty-six Hereford × Angus steers, which had been fed for 140-155 days to an avg BW 1181 lb, were stunned, shackled by a rear leg, and exsanguinated through the severed jugular veins. Cattle were infused to 10% of live weight via the carotid artery using a technique developed by the Meat Processing Service Corporation of Eden Prairie, MN. They were assigned randomly to one of the following treatments: 1. noninfused, control; 2. infused with a water solution containing a mixture of sugars and phosphate; and 3. infused with water and 0.3M $CaCl_2$. After infusion, cattle were processed using normal procedures and placed in a 36° F cooler with a spray-chill system. Muscle pH decline was measured at 1, 2, 4, 8, 16, and 24 hr postmortem in the *triceps brachii (TB), longissimus thoracis,* and inside (deep) *semimembranosus* (ISM). Carcass temperature decline in these three muscles also was monitored continuously for 24 hr after cooler entry. At 48 hr postmortem, the *longissimus lumborum* (LL), *psoas major* (PM), and *semimembranosus* (SM) muscles were excised, trimmed practically free of fat, vacuum packaged in barrier bags, and vacuum aged for 12 days at 36° F. One-inch-thick steaks from these muscles were packaged in permeable film for display in an open-topped case at 35° F with two defrost cycles daily and illumination at 150 foot- candles of Deluxe Warm White fluorescent lighting. Steaks were evaluated by a six-member, trained, color panel for initial color, color uniformity, and color stability over 4 or 5 days of display. The SM typically has a light-red inside portion (ISM) and a darker red outside portion (OSM). Thus, these two muscle areas were scored separately. Color was evaluated instrumentally throughout display. Significant differences ($P<.05$) were determined using analysis of variance.

Results and Discussion

Carcass pH Decline: A more rapid pH decline (Table 1) occurred in the three muscles from the infused carcasses versus pH decline in noninfused carcasses. It took 16 h for pH decline in noninfused longissimus thoracis (LT) to equilibrate with pH decline in the two infused treatments. In the TB and ISM muscles, pH decline in control carcasses equaled the pH decline in the infused carcasses by 4 hr postmortem. All treatments within a muscle had essentially the same muscle pH at 24 hr postmortem. The accelerated pH declines of both infusion treatments while carcass temperatures were high (1-4 hr postmortem) created conditions favorable for protein denaturation, which could result in a lighter color and softer muscle.

Muscle pH: No differences in 48 hr pH occurred among treatments for the LL (5.71), ISM (5.74), and OSM (5.69) muscles. The PM from carcasses infused with sugar/phosphate had a higher (*P*<.05) pH (5.89) than PM from noninfused carcasses (5.78). The pH of PM steaks from carcasses that were $CaCl_2$-infused (5.83) was not different (*P*>.05) from that of PM steaks.

Initial Color and Uniformity of Color: LL and OSM muscles from carcasses infused with sugar/phosphate had lighter, more cherry red, initial color scores (*P*<.05) than steaks from the $CaCl_2$-infused or noninfused carcasses (Table 2). Differences in initial scores likely were due to increased light scatter caused by water added during infusion and/or the more rapid pH declines, not muscle pigment dilution.

The LL from noninfused carcasses was most uniform in color (*P*<.05), and both the sugar/phosphate-infused and $CaCl_2$-infused treatments had more two-toning. The $CaCl_2$-infused treatment created a speckled or mottled brownish-red appearance that would not be acceptable for meat purveyors or consumers.

Display Color Stability: The obvious trend was for visual color stability scores to increase (more discoloration) as time progressed (Table 3). On day 0, LL steaks from the sugar/phosphate treatment had the lightest-red (*P*<.05) appearance. These steaks discolored faster but to the same final color as the control. In the LL, the $CaCl_2$-infused and noninfused treatments were not different for visual scores at day 0, but at day 1 of display and over the display period, the $CaCl_2$-infused treatment resulted in more discoloration than did the sugar/phosphate and noninfused treatments. Apparently, the $CaCl_2$-infusion caused a faster conversion of the bright-red pigment to enough of the brown form of myoglobin to be perceptible to color panelists. Treatment differences in display color stability were not as pronounced in the ISM and OSM muscles (data not shown), but they tended to follow the differences found in the LL. Instrumental color evaluations confirmed the visual scores for discoloration. Muscles from the sugar/phosphate treatment were lighter-red and discolored similarly to steaks from non-infused carcasses, whereas the $CaCl_2$ infusion increased discoloration.

Infusion treatment differences were found for the LL, so infusion solutions must have reached that muscle. Pumping aqueous solutions to areas nearer the infusion site should be easier than pumping to muscles located in posterior portions of the carcass. Some treatment differences due to infusion were found in the ISM and OSM. Thus, vascular infusion apparently delivered substrates to these posterior muscles of the carcass, although faster pH decline postmortem may have contributed. Vascular infusion of beef carcasses is not approved currently by the USDA, but it has potential to positively alter some carcass and muscle traits.

Table 1. pH Decline Means by Treatment and Muscle from Carcasses that Were Vascularly Infused with Sugar/Phosphate or $CaCl_2$ Immediately after Bleeding

	Muscle		
Time × treatment	*Triceps brachii*	*Longissimus thoracis*	Inner *Semimembranosus*
1 h			
$CaCl_2$-infused	5.96[b]	6.23[b]	6.44[b]
Sugar-infused	6.12[b]	6.21[b]	6.23[c]
Noninfused	6.58[a]	6.87[a]	6.67[a]
2 h			
$CaCl_2$-infused	5.64[c]	5.84[b]	6.01[b]
Sugar-infused	5.84[b]	5.96[b]	5.90[b]
Noninfused	6.25[a]	6.50[a]	6.20[a]
4 h			
$CaCl_2$-infused	5.56	5.63[c]	5.61
Sugar-infused	5.69	5.81[b]	5.73
Noninfused	5.69	6.13[a]	5.68
8 h			
$CaCl_2$-infused	5.59	5.58[b]	5.57
Sugar-infused	5.65	5.64[ab]	5.55
Noninfused	5.58	5.81[a]	5.56
16 h			
$CaCl_2$-infused	5.64	5.69	5.65
Sugar-infused	5.60	5.64	5.58
Noninfused	5.56	5.66	5.63
24 h			
$CaCl_2$-infused	5.66	5.62	5.54
Sugar-infused	5.68	5.64	5.58
Noninfused	5.64	5.65	5.64
SE	0.09	0.09	0.09

[a,b,c]Means within a muscle and postmortem time with a different superscript letter differ ($P<.05$).

Table 2. Least Square Means for Initial Color Score, Color Uniformity Score, a*, and %R630-580nm of Steaks from Carcasses Vascularly Infused with Sugar/ Phosphate or $CaCl_2$ Immediately after Bleeding

	Visual Color[d]		Instrumental Color[d]	
Muscle × Treatment	Initial[e]	Uniform[f]	a*	%R630-580 nm
Inside semimembranosus (ISM)				
$CaCl_2$-infused	2.4	1.3	13.8	19.5
Sugar-infused	1.9	1.2	13.8	22.5
Noninfused	2.3	1.3	15.2	20.7
SE	0.34	0.14	0.77	1.50
Outside semimembranosus (OSM)				
$CaCl_2$-infused	4.4[a]	1.4	18.2	19.8
Sugar-infused	3.5[b]	1.4	17.7	22.3
Noninfused	4.4[a]	1.3	18.3	20.2
SE	0.34	0.14	0.77	1.50
Longissimus lumborum (LL)				
$CaCl_2$-infused	4.0[a]	2.2[a]	15.6[c]	19.3[b]
Sugar-infused	3.1[b]	1.8[b]	18.9[b]	27.0[a]
Noninfused	4.2[a]	1.2[c]	20.7[a]	24.5[a]
SE	0.34	0.14	0.77	1.50
Psoas major (PM)				
$CaCl_2$-infused	4.3	1.7	12.4	12.9
Sugar-infused	3.9	1.6	13.3	15.7
Noninfused	4.2	1.5	12.8	14.1
SE	0.34	0.14	0.83	1.61

[a,b,c]Means within a muscle group for a given trait with a different superscript letter differ ($p<.05$).

[d]These visual scores and instrumental data had a two-way interaction ($p<.05$) with treatment and muscle and no significant three-way interactions (treatment x muscle x display day), both a* and %R630-580 nm indicate redness.

[e]Initial color scale for d 0 only: 1=pale red or bleached red, 2=very light cherry red, 3= moderately light cherry red, 4=cherry red, 5=slightly dark cherry red, 6=moderately dark red, 7=dark red, and 8=very dark red.

[f]Color uniformity scale for d 0 only: 1=uniform, 2=slight two-toning, 3=small amount of two-toning, 4=moderate amount of two-toning, 5=extreme two-toning.

Table 3. Least Square Means for Visual Display Color, L*, and b* for the *Longissimus Lumborum* from Carcasses Vascularly Infused with Sugar/Phosphate or $CaCl_2$ Immediately after Bleeding

Display Day/Treatment	Visual Display Color[d]	L*	b*
d 0			
$CaCl_2$-infused	2.5[a]	40.9[ab]	23.0[ab]
Sugar-infused	1.9[b]	43.4[a]	24.0[a]
Noninfused	2.4[a]	38.7[b]	22.4[b]
d 1			
$CaCl_2$-infused	3.2[a]	40.5[ab]	20.9[b]
Sugar-infused	2.2[b]	43.2[a]	22.5[a]
Noninfused	2.6[b]	38.1[b]	21.8[ab]
d 2			
$CaCl_2$-infused	3.9[a]	40.3[ab]	19.8[b]
Sugar-infused	2.8[b]	42.6[a]	22.2[a]
Noninfused	2.9[b]	37.9[b]	21.4[a]
d 3			
$CaCl_2$-infused	4.2[a]	39.8[ab]	19.0[b]
Sugar-infused	3.1[b]	41.9[a]	22.0[a]
Noninfused	3.2[b]	37.4[b]	21.0[a]
d 4			
$CaCl_2$-infused	4.3[a]	41.1[ab]	17.4[b]
Sugar-infused	3.4[b]	43.5[a]	20.2[a]
Noninfused	3.2[b]	38.8[b]	19.5[a]
d 5			
$CaCl_2$-infused	4.5[a]	41.4[ab]	18.3[b]
Sugar-infused	3.6[b]	42.7[a]	20.5[a]
Noninfused	3.4[b]	38.8[b]	19.8[a]
SE	0.16	1.33	0.53

[a,b]Means within a column on a given day with a different superscript letter differ ($P<.05$).
[c]The OSM, ISM, and LM were the only muscles were significant ($P<.05$) differences were found for visual display scores, L* and b* values.
[d]1= very bright cherry red or pale red, 3 = slightly dark red to tan or brown, 5 = dark red to tan or brown.