CARCASS CHILLING METHOD EFFECTS ON COLOR AND TENDERNESS OF BISON MEAT

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Abstract –The objective was to determine the effect of carcass vascular rinsing and chilling on color and tenderness of bison meat. Carcasses were conventionally chilled (C, n=9) or rinsed and chilled (RC, n=9). Muscles (*M. Longissimus et lumborum*, LL; *M. Triceps brachii,* TB) were processed (LL, steaks; TB, ground), packaged (polyvinyl chloride, PVC; vacuum, VAC), and displayed (1615 lux) or dark stored (2 °C). Color, purge, pH, sarcomere length, Warner-Bratzler shear (WBS), and cooking loss were determined. Data were analyzed as a factorial design (2 x 2; chilling method by packaging, with a storage day split plot factor). RC increased (P<0.05) cooking loss by 1.7%. However, RC decreased WBS by 24% (C, 4.33 kgf; P<0.05) in aged steaks. RC PVC steaks were less red (CIE *a; P<0.05) and had more (P<0.05) metmyoglobin on day 7 than C steaks. VAC RC steaks had more (P<0.05) deoxymyoglobin than C (day 7). In PVC, ground RC bison resulted in higher (P<0.05) CIE *a** than C (day 4) while VAC ground RC bison was more (P<0.05) red and had greater deoxymyoglobin than C (day 1, 4). RC technology has potential to positively impact bison steak tenderness and increase redness in ground bison.**

Key Words – Bison, carcass chilling and rinsing, meat quality.

I. INTRODUCTION

Post-exsanguination vascular infusion has been studied to determine the effects on postmortem metabolic changes, water holding capacity, meat color, and palatability [1]. Some of the research focused on infusing $CaCl_2$ in lamb, grain-fed Hereford x Angus steer beef, and Brahman-cross beef as a means to enhance proteolysis [2,3,4]. Others investigated infusion with a solution of saccharides, sodium chloride, phosphates, and vitamin C to influence the flavor profile of beef [5]. The objective of this study was to determine the effect of early postmortem carcass vascular rinsing and chilling on color and tenderness of bison bull meat in comparison to conventional carcass chilling.

II. MATERIALS AND METHODS

Two chilling methods were implemented on carcasses that had an average hot carcass weight of 231.9 kg (standard deviation, 57.5) from 28 month old bison bulls. Nine carcasses were conventionally chilled (C) and nine were chilled with MPSC Incorporated Rinse and Chill® technology (RC) on one slaughter day at a commercial plant in Colorado. The RC process involves vascular rinsing of the residual blood early postmortem using a chilled (3 °C) isotonic substrate solution (98.5% water; balance: glucose, polyphosphates, glycerine, and maltose).

At 24 h postmortem, the *M. Longissimus et lumborum* (LL) and *M. Triceps brachii* (TB) muscles were excised, vacuum packaged, and shipped overnight with freezer ice packs to UW-Madison (averaged 4.4°C internal upon delivery). On day 2 postmortem, each individual TB was ground (model 548 J11; Biro Manufacturing Co., Marblehead, Ohio) through two plates (9.53 mm, 4.76 mm). LL muscles were cut into steaks (25.4 mm thick). Steak and ground bison samples were overwrapped with oxygen permeable polyvinyl chloride film (PVC; oxygen transmission rate, OTR: 22,480 $cm^3/m^2/24$ h at 23 °C; water transmission rate = 496 g/ $m^2/24$ h at 37.8 °C and 90% relative humidity; product code 75003815, AEP Industries Inc., South Hackensack, NJ) using a single-roll over-wrapper (product code 38210030, Bunzl-Koch Supplies, Kansas City, MO) on a styrofoam tray. PVC wrapped steaks and PVC wrapped ground bison were continuously displayed in an open-topped refrigerated (1-2 °C)

display case (model LCM 1230; Master-Bilt, New Albany, MS) under fluorescent lighting (40 watt, F40/CWX, Sylvania Cool White Deluxe, Danvers, MA) that provided approximately 1076 lux. The remaining steak and ground bison samples were individually vacuum packaged (vacuum setting, 10/10; model 2100-C; UltraVac-dual chamber; Koch Equipment LLC., Kansas City, MO) in plastic pouches (2.7 mil thick, OTR 3-6cc/ m^2/24h atm @ 4 °C, 0% relative humidity, blend of very low density polyethylene and ethylene vinyl acetate copolymer, 18 x 30 cm, product code 9KN81, Sealed Air Corporation). VAC samples were stored in the dark (1-2 °C).

Color measurements (CIE *L*a*b**; reflectance estimators of chemical states of myoglobin) were obtained on 1, 4, and 7 d except for PVC ground TB which excluded day 7. Six colorimeter measurements and two spectrophotometric measurements were obtained on each LL and TB sample at every time interval. Meat surface color was measured using a colorimeter (model CR-300, 8-mm aperture, 0° viewing angle; Minolta Camera Co., Ltd., Osaka, Japan) calibrated with a standard white plate (No. 18133019; D65 light source; Y=92.6, x=0.3162, y=0.3324) overwrapped with the applicable film. A UV-Visible scanning reflectance spectrophotometer was used to determine the chemical states of myoglobin. The spectrophotometer (UV-2501, Shimadzu) was set to scan from 400 to 700 nm in the reflectance mode (fast scan speed, 1.0 nm sampling interval, 5.0 nm slit width) with an attached integrating sphere (model MPC-2200) and UV Probe Version 2.34. The chemical states of myoglobin were estimated by the following reflectance wavelength combinations: deoxymyoglobin (DMb, percentage reflectance at 474 nm / percentage reflectance at 525 nm), metmyoglobin (MMb, %R572 nm / %R525 nm), and oxymyoglobin (OMb, %R610 nm / %R 525 nm) recommended by AMSA [6]. Other dependent variables included purge (2 days postmortem), pH, sarcomere length, Warner-Bratzler shear (WBS; 1-cm wide by 1-cm thick strips parallel to the muscle fibers), and cooking loss. Purge was measured two days postmortem. Percentage purge was based on the total net weight of the meat in the package before opening the bag and draining the purge. To determine pH, ground samples (in duplicate) were separately homogenized in a mini container (model MC2) using a blender (model 700S, Waring Blender). The homogenate was filtered before readings were taken using a pH meter (model PB-11-P11-1, Sartorius pH Basic with a glass electrode). Samples for laser sarcomere determination [7] were cut into roughly 25 cm^3 and stored in a 5% glutaraldehyde, 0.1 M NaHPO4 buffer (pH=7.2) solution for four hours at 4 °C. This solution was then replaced with a 0.2 M sucrose, 0.1 M NaHPO4 buffer solution (pH=7.2) overnight at 4 °C. Muscle fibers were teased out of each fixed sample the following morning and measured (n=6) under a helium-neon laser (model R-30989, 633 nm, 500:1 polarization, 2.0mW; Newport Corp., Irvine, CA). The distance from the specimen to the diffraction pattern screen was 100 mm and sarcomere length was calculated according to Cross *et al.* [7]. Steaks were cooked on an electric grill (model GGR50; George Foreman Grill) with the heat dial set a 3.5. A 12-channel thermocouple scanner (model 920000-00; Digi-Sense; Cole-Parmer Instrument Company, Vernon Hills, IL) was used to measure the internal steak temperature via needle probe thermocouples (Type K; Electronic Temperature Instruments LTD West Sussex BN14 8NW UK). Four steaks were placed on the grill at a time and each were flipped when the internal temperature reached 41 °C. The steaks were pulled off the grill once the temperature was 68 °C. Cooking loss was observed by measuring the raw weight of the steak samples compared to the cooked weight. These steaks were stored overnight in a cooler and brought out in the morning to warm up to room temperature. Eight samples were cut from each steak parallel to the muscle fibers for tenderness evaluation. Tenderness was instrumentally measured (Warner-Bratzler Shear Apparatus, G-R Electric manufacturing, Manhattan, Kansas) with a V-notched blade. Samples were sheared perpendicular to the muscle fibers [8]. For the statistical analysis, animal served as the experimental unit. Data were analyzed as a 2 x 2 factorial (chilling method by packaging) with a storage day split plot factor. The SAS MIXED procedure (SAS 9.1.3 Service Pack 3, SAS Institute Inc., Cary, NC, USA) was used to determine significance ($P<0.05$) in the model and when significance was found, means were separated using the Least Significant Difference

method. Letter assignment to individual means to enable statistical comparisons was achieved using the pdmix800 macro [9].

III. RESULTS AND DISCUSSION

Chilling method did not influence (P>0.05) the ultimate pH (Table 1). Vascular infusion with a similar solution [4] resulted in a more rapid decline in pH but as reported here did not alter the ultimate pH. RC resulted in greater (P<0.05) purge than C with differences of 0.38% (LL) and 0.51% (TB). However, RC did not affect sarcomere length. Although RC increased (P<0.05) cooking loss by 1.7%, this process decreased (P<0.05) WBS by 24% in aged steaks (10 d postmortem). In contrast, Yancey *et al.* [5] did not find any difference in the tenderness of the LL from Charolais cattle carcasses vascularly infused. However, Dikeman *et al.* [4] reported the LL was less tender than the control but they found an increase in tenderness in the semitendinosus muscle from Hereford x Angus steers.

Table 1. Least square means on the effects of carcass chilling treatment on two muscles[1].

Dependent	LL		TB		
variables[2]	C	RC	C	RC	SED
pH	5.44^{b}	5.43^{b}	5.63^{a}	5.64^{a}	0.012
Purge (%)	0.50^{b}	0.88^{a}	0.18^{c}	0.69^{ab}	0.107
SL (μ)	1.77^{ab}	1.80^{a}	1.61^{b}	1.66^{ab}	0.059
CL (%)	12.74^{b}	14.43^{a}	na	na	0.574
WBS (kgf)	4.33^{ab}	3.28^{b}	na	na	0.294

[1]Carcass chilling treatment: C=control, RC=rinse and chill; Muscles: LL= *M. Longissimus et lumborum*, TB= *M. Triceps brachii.*

[2]Dependent variables: pH, on raw samples; SL, sarcomere length; CL, cooking loss; WBS, Warner-Bratzler Shear.

[a-c]Means within a row with unlike superscript letters are different (P<0.05). SED, standard error of the difference.

RC PVC wrapped steaks were less (P<0.05) red than C steaks on day 7 and had a higher estimated metmyoglobin (MMb) than C steaks on day 7 (Table 2). Our results confirm those of Hunt *et al.* [10] as they found the LL from infused carcasses were lighter red. No other color differences (P>0.05: CIE *a**, oxymyoglobin, OMb; deoxymyoglobin, DMb; MMb) were found for PVC wrapped steaks regardless of chilling method. Only one difference for color was found in VAC RC which had a higher (P<0.05) estimated DMb than C on day 7.

Table 2. Least square means of carcass chilling treatment effects on CIE *a** and reflectance estimators of the chemical states of myoglobin on refrigerated packaged bison *M. Longissimus et lumborum* steaks under continuous lighting display (PVC) and non-displayed (vacuum packaged) conditions[1].

	PVC		VAC	
Storage Day	C	RC	C	RC
		CIE *a**		
1	19.37^{a}	19.47^{a}	14.92^{bc}	15.34^{b}
4	16.42^{b}	15.84^{b}	15.60^{b}	16.02^{b}
7	13.63^{c}	11.39^{d}	16.00^{b}	16.43^{b}
		Oxymyoglobin		
1	2.27^{a}	2.37^{a}	1.62^{e}	1.52^{de}
4	2.01^{b}	1.82^{c}	1.65^{de}	1.58^{de}
7	1.69^{cd}	1.52^{e}	1.63^{de}	1.61^{de}
		Deoxymyoglobin		
1	1.12^{de}	1.13^{d}	1.47^{c}	1.49^{c}
4	1.10^{de}	1.09^{de}	1.50^{bc}	1.53^{ab}
7	1.09^{de}	1.08^{e}	1.49^{c}	1.56^{a}
		Metmyoglobin		
1	0.81^{de}	0.79^{e}	0.85^{d}	0.84^{de}
4	0.86^{cd}	0.90^{c}	0.82^{de}	0.79^{e}
7	0.95^{b}	1.03^{a}	0.83^{de}	0.79^{e}

[1]Carcass chilling treatment: C=control, RC=rinse and chill. Dependent variables: CIE *a**, larger number more red; Reflectance (R) estimators of myoglobin chemical states: oxymyoglobin (%R610nm/%R525nm), deoxymyoglobin (%R474nm/%R525nm), metmyoglobin (%R572nm/%R525nm), larger values indicate more of that state.

[a-e]Means within a dependent variable with unlike superscript letters are different (P<0.05). Standard error of difference: CIE *a** = 0.601, oxymyoglobin = 0.0643, deoxymyoglobin = 0.0150, and metmyoglobin = 0.0177

In PVC ground bison, RC resulted in higher (P<0.05) CIE *a** than C on day 4 (Table 3). No reflectance differences associated with chilling method were found in the PVC ground bison. In

VAC ground bison, RC meat was more red (CIE *a**) on day 1 and 4 than C. Also RC had greater DMb (day 1, 4) than C.

Table 3. Least square means of carcass chilling treatment effects on CIE *a** and reflectance estimators of the chemical states of myoglobin on refrigerated packaged ground bison *M*. T*riceps brachii* under continuous lighting display (PVC) and non-displayed (vacuum packaged) conditions[1].

	PVC		VAC	
Storage Day	C	RC	C	RC
		CIE *a**		
1	15.41^{d}	15.97^{cd}	15.40^{d}	16.85^{ab}
4	9.54^{f}	10.34^{e}	16.15^{bc}	17.02^{a}
		Oxymyoglobin		
1	1.93^{a}	1.95^{a}	1.51^{c}	1.58^{bc}
4	1.48^{c}	1.53^{c}	1.68^{b}	1.67^{b}
		Deoxymyoglobin		
1	1.11^{e}	1.11^{e}	1.46^{d}	1.52^{c}
4	1.08^{f}	1.08^{f}	1.57^{b}	1.59^{a}
		Metmyoglobin		
1	0.92^{b}	0.91^{b}	0.85^{c}	0.83^{cd}
4	1.17^{a}	1.16^{a}	0.80^{de}	0.79^{e}

[1]Carcass chilling treatment: C=control, RC=rinse and chill. Dependent variables: CIE *a**, larger number more red; Reflectance (R) estimators of myoglobin chemical states: oxymyoglobin (%R610nm/%R525nm), deoxymyoglobin (%R474nm/%R525nm), metmyoglobin (%R572nm/%R525nm), larger values indicate more of that state.

[a-f]Means within a dependent variable with unlike superscript letters are different (P<0.05). Standard error of difference: CIE *a** = 0.360, oxymyoglobin = 0.0143, deoxymyoglobin = 0.0068, and metmyoglobin = 0.0123

IV. CONCLUSION

Rinse and Chill technology has commercial potential to positively impact bison steak tenderness in addition to increasing redness in packaged ground bison.

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