Effects of Pre-harvest Electrolyte Supplementation on the Hydration and Meat Quality of Cull Dairy Cows

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Pre-harvest electrolyte treatment of cull dairy cows improved beef quality and animal hydration, especially when cows were subject to periods of hot, humid weather and a longer feed withdrawal. However, electrolyte treatment did not affect dressing percentage.

Summary

Two studies were conducted to evaluate the effect of pre-harvest electrolyte supplementation on the hydration and beef quality of cull dairy cows. Cows were withheld from feed prior to harvest for 36 or 24 h and ambient temperature ranged from 72 to 90°F or from 54 to 63°F for Exp. 1 and 2, respectively. In Exp. 1, cull dairy cows (n = 60) were orally drenched with 0.4 gal of water (CON; n = 30) or 0.4 gal of water containing 1.09 g of dry electrolyte/lb BW prior to transportation to a processing facility (PRE; n = 30). Cows treated PRE tended (P = 0.06) to remain more hydrated than CON-cows throughout the pre-harvest period. Ribeye samples from PRE cows exhibited greater drip loss (P = 0.04) and tended (P = 0.06) to have a lower 24-h pH than samples from CON cows. In Exp. 2, cull dairy cows (n = 46) were either drenched with electrolyte prior to transport (PRE; n = 16), following transport (POST; n = 14), or given a placebo volume of water (CON; n =16). Cows treated PRE tended to have a lower (P = 0.06) percentage of weight loss during transport than untreated cows. Pre-harvest electrolyte treatment of cull dairy cows improved beef quality and animal hydration, especially when cows were subject to periods of hot weather and a longer feed withdrawal.

Introduction

The transportation and handling of cattle destined for harvest are stressors which can reduce live weight and dressing percentage and effect meat quality. Considerable research has been conducted with electrolyte supplementation of growing (Cole and Hutcheson, 1985) and finishing cattle (Schaefer et al., 1999), however, no known work has been reported with cull cows. Therefore, two experiments were conducted to assess the impact of dietary electrolyte supplementation on weight loss, hydration, and meat quality of cull dairy cows when supplemented prior to, or immediately following transportation to harvest facilities.

Materials and Methods

Experiment 1

Sixty culled, lactating dairy cows were used in Exp. 1 which was conducted over 4 d in mid-August, 2009 at a commercial dairy operation in Okeechobee County, Florida. Cows in both studies were selected based on low milk production, reproductive failure, and lameness. Ambient temperature ranged from 72 to 90°F, with an average relative humidity of 75% for the live cattle portions of the study. At 12 h prior to the start of the study, cows were removed from feed, initial body weight (BW) was collected, and cows were assigned a subjective locomotion score (1 = normal to 5 = severely lame; Sprecher et al., 1997). Cows were offered water ad libitum through the duration of both studies, except during transportation. Cows were stratified by initial BW and days in lactation (DIL) into either the control treatment (CON) or on-farm electrolyte supplemented treatment (PRE).

At 5:00 a.m. the following morning, cows were placed in a squeeze chute, ear tagged and blood

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sampled. A dry electrolyte powder (Table 1) delivered at 1.09 g/lb of initial BW was dissolved in 0.4 gal of water. Cows (PRE; n = 30) were orally drenched with 0.4 gal of electrolyte solution or a placebo volume of water (CON; n = 30). At 5:00 p.m. cows were loaded and transported 3 h to a commercial beef processing facility. Cows were unloaded and given 7.5 h of rest. At 3:30 a.m. cows were weighed and blood sampled as described earlier, prior to being harvested at 7:00 a.m.

Experiment 2

Forty-eight culled, lactating dairy cows were used in Exp. 2 which was which was conducted over 4 d in mid-December, 2009 at a commercial dairy operation in Gilchrist County, Florida. Cows from Exp. 2 were selected using the same criteria as Exp. 1. Ambient temperature ranged from 54 to 63°F, with an average relative humidity of 87% for the live cattle portion of the study. On d 1, cows were stratified by initial BW and DIL into 1 of 3 treatment groups: 1) untreated control (CON); 2) on-farm electrolyte supplementation before transportation (PRE); and 3) post-transportation electrolyte supplementation (POST).

At 5:00 a.m. the following morning, cows were withheld from feed and blood sampled. For the PRE- treatment, cows (n = 16) were orally drenched the same as in Exp. 1, whereas CON- and POST-cows (n = 16 and 14, respectively) received a placebo volume of 0.4 gal of water. At 2 p.m. cows were loaded and transported 2 h to a commercial beef processing facility, unloaded and placed in holding pens. At 5 p.m. cows were weighed and samples collected as described earlier. Cows (POST; n = 14) were administered an electrolyte treatment using the previously described procedure, with CON- and PRE- cows given a placebo volume of 0.4 gal of water before being returned to their holding pens. At 4 a.m. cows were weighed and sampled as described earlier, prior to being harvested at 10:00 a.m.

Carcass data, pH, and objective lean color (L*, a*, b*) of the ribeye (RE) and semimebranosus (SM) were collected by university personnel, for both experiments, at 24-h postmortem from left carcass sides.

Data were analyzed as a completely randomized design with individual cow as the experimental unit for all variables measured. The mixed models procedure of SAS (SAS Inst. Inc., Cary, NC) was used to test the model. Locomotion score and DIL were used as covariates in both models. Least square means were calculated for the lone fixed effect of electrolyte treatment, and separated statistically using pair-wise t-tests (*P*-DIFF option of SAS) when a significant ($P<0.05$) F-test was detected.

Results

Initial and pre-harvest BW were similar across treatments in Exp. 1 and 2. However, in Exp. 2, BW shrink during transportation tended to be less ($P = 0.06$) in PRE-cows than in CON- and POST-cows (8.58 vs 12.45 % loss, respectively). The tendency for electrolyte-treated cows to lose less BW than untreated cows is consistent with the findings of Gortel et al. (1992) and may be attributed to an increase in water intake in response to increased sodium intake.

In Exp. 1, PRE-cows tended ($P \leq 0.08$) to have lower packed cell volume (PCV) values, an indicator of improved cell hydration, throughout the pre-harvest period than CON-cows (Table 2). Electrolyte treatment did not affect PCV values of cows in Exp. 2.

Carcasses of PRE-cows had more ($P = 0.03$) marbling within the ribeye than carcasses of CON- or POST-cows in Exp. 2 (Table 3). Otherwise, electrolyte supplementation did not affect ($P \geq 0.12$) any carcass trait in Exp. 1 or 2 (Table 3).

The RE of PRE-cows tended ($P = 0.06$) to have a lower 24-h pH value compared to the RE of CON-cows in Exp. 1 (Table 4). Electrolyte supplementation did not affect pH ($P \geq 0.35$) of either muscle in Exp. 2, nor the SM in Exp. 1 (Table 4). Beef products with elevated pH values are undesirable due to having a reduced product shelf-life (Faustman and Cassens, 1990) and potentially resulting in ground beef with some degree of redness remaining after cooking, or “persistent pinking” (Hunt et al., 1999). The elevated RE pH values in Exp. 1 were likely impacted by handling cows multiple times for blood collection and weighing in the hot, humid environment. Electrolyte supplementation of fed cattle has been shown to increase muscle glycogen antemortem, allowing for a more complete postmortem pH decline of postmortem muscle (Schaefer et al., 1999).

The RE from CON-cows had a lower (*P* = 0.04) drip loss percentage than the RE from PRE-cows in Exp. 1 (Table 4). Objective color (L*, a*, and b*) values of the RE and SM did not differ (*P* ≥ 0.11) between treatments in either Exp. 1 or 2 (Table 4). However, in Exp. 1, SM samples from PRE carcasses had numerically greater L* and a* values than samples than CON carcasses, suggesting a relationship to the lower, more normal final pH exhibited by PRE cows. Beef with a 24-h pH closer to 5.2, the isoelectric point of muscle, would be expected to have decreased water-holding capacity and a lighter color (Lawrie, 1958).

Conclusion

Pre-harvest electrolyte treatment of cull dairy cows improved beef quality and animal hydration, especially when cows were subject to periods of hot, humid weather and a longer feed withdrawal. However, non-fed beef processors in the U.S. primarily purchase cull cows on carcass weight; thus, dressing percentage is of paramount importance. More trials with a greater number of animals, varying electrolyte dosages, and times of delivery should be conducted to determine if pre-harvest supplementation can increase dressing percentage of cull cows. Also, future trials should incorporate the electrolyte within the water source, allowing ad libitum access, to simulate commercial applications. Electrolyte supplementation costs were approximately $ 2 – 5/cow in the current research; therefore, increased value from improved dressing percentage and beef quality will have to exceed supplementation costs to be commercially viable.

Literature Cited

Cole and Hutcheson. 1985. J. Anim. Sci. 60:772.
Faustman and Cassens. 1990. J. Muscle Foods 1:217.
Gortel et al.1992. Can. J. Anim. Sci. 72:547.
Hunt et al. 1999. J. Food Sci. 64:847.
Lawrie 1958. J. Sci. Food Agric. 9:721.
Schaefer et al. 1999. Can. J. Anim. Sci. 79:592.
Sprecher et al. 1997. Theriogenology. 47:1179–1187.
USDA-AMS. 1997. United States standards for grades of carcass beef.

The authors would like to sincerely thank Mr. Jacob Larson and his staff at Larson Dairy Inc., Okeechobee, FL and Mr. Don Bennick and his staff at North Florida Holsteins, Bell, FL. The authors would also like to thank the management and staff at Central Beef Industries LLC, Center Hill, FL.

Table 1. Ingredients of electrolyte supplement

Ingredient	%
Dextrose	94.8
Sodium bicarbonate	2.7
Potassium chloride	1.5
Magnesium sulfate	1.0

Table 2. Effect of on-farm electrolyte supplementation on packed cell volume (PCV) of whole blood for Exp. 1

	Treatment[1]			
Variable	CON	PRE	SEM	*P*-Value
Initial PCV, %	35.85	35.34	0.70	0.62
Pre-harvest PCV, %[c]	36.40	34.62	0.68	0.08
PCV Change, %	1.63	-1.74	1.20	0.06

[1]CON; orally drenched with 0.4 gal of water. PRE; orally drenched with 0.4 gal of water containing 2.4 g of dry electrolyte per kg BW

[2]From blood taken approximately 36 h after initial measurement and feed withdrawal.

Table 3. Carcass characteristics by treatment group for Exp. 1 and 2

	Exp. 1			Exp. 2			
Treatment[1]	CON	PRE	*P*-Value	CON	PRE	POST	*P*-Value
No. of observations	30	30		16	16	14	
Dressing %	53.0 ± 0.7	53.2 ± 0.7	0.83	51.1 ± 1.1	50.1 ± 1.1	49.8 ± 1.2	0.65
Hot carcass wt, lbs	728.9 ± 21.6	670.1 ± 21.6	0.51	724.7 ± 26.2	708.1 ± 26.2	309.0 ± 28.4	0.54
Fat thickness, in	0.20 ± 0.03	0.19 ± 0.03	0.93	0.11 ± 0.03	0.12 ± 0.03	0.05 ± 0.03	0.22
Ribeye area, sq. in	10.5 ± 0.4	10.5 ± 0.4	0.94	9.1 ± 0.5	9.3 ± 0.5	8.9 ± 0.5	0.84
USDA YG[2]	2.8 ± 0.1	2.7 ± 0.1	0.65	3.1 ± 0.1	3.0 ± 0.1	2.9 ± 0.2	0.58
Overall Maturity[3]	432 ± 18	407 ± 18	0.32	418 ± 30	430 ± 30	506 ± 32	0.12
Marbling[4]	408 ± 28	426 ± 28	0.66	392 ± 39[ab]	459 ± 39[a]	302 ± 42[b]	0.03

[1]CON = orally drenched 0.4 gal of water before (Exp. 1) or before and after transportation (Exp. 2); PRE = orally drenched with 0.4 gal of water containing 1.09 g of dry electrolyte/lb BW before transportation; POST = orally drenched with 1.5 L of water containing 1.09 g of dry electrolyte/lb BW after transportation

[2]A standard 2.5% KPH fat was used when calculating USDA yield grades (USDA-AMS, 1997).

[3]200 to 299 = B maturity; 300 to 399 = C maturity; 400 to 499 = D maturity; 500 to 599 = E maturity.

[4]300 to 399 = Slight; 400 to 499 = Small; 500 to 599 = Modest.

[a,b]Within a row, values lacking a common superscript differ ($P<0.001$).

Table 4. Effect of electrolyte supplementation on pH and objective color measurements of the ribeye (RE) and semimembranosus (SM) and RE drip loss for Exp. 1 and 2

	Exp. 1			Exp. 2			
Treatment[1]	CON	PRE	*P*-Value	CON	PRE	POST	*P*-Value
No. of observations	30	30		16	16	14	
3-h RE pH	-	-	-	7.02 ± 0.07	7.14 ± 0.07	7.03 ± 0.07	0.43
24-h RE pH	5.91 ± 0.04	5.81 ± 0.04	0.06	5.67 ± 0.03	5.69 ± 0.03	5.68 ± 0.03	0.89
RE Lightness (L*)[2]	32.99 ± 0.82	34.38 ± 0.82	0.25	22.62 ± 0.99	22.10 ± 0.99	20.63 ± 1.07	0.39
RE Redness (a*)[3]	18.43 ± 0.60	19.25 ± 0.60	0.35	25.28 ± 0.77	24.17 ± 0.77	24.51 ± 0.83	0.58
RE Yellowness (b*)[4]	15.08 ± 0.45	15.99 ± 0.45	0.17	20.41 ± 0.62	19.11 ± 0.62	19.17 ± 0.67	0.27
RE drip loss, %	0.61 ± 0.21	1.26 ± 0.21	0.04	1.79 ± 0.27	1.20 ± 0.27	0.91 ± 0.30	0.10
24-h SM pH	5.90 ± 0.03	5.85 ± 0.03	0.35	5.64 ± 0.03	5.66 ± 0.03	5.67 ± 0.03	0.81
SM Lightness (L*)[2]	28.32 ± 0.78	29.80 ± 0.78	0.19	20.42 ± 1.30	19.95 ± 1.30	21.48 ± 1.41	0.73
SM Redness (a*)[3]	20.40 ± 0.66	21.95 ± 0.66	0.11	25.68 ± 1.04	27.55 ± 1.04	25.95 ± 1.13	0.40
SM Yellowness (b*)[4]	15.78 ± 0.63	17.25 ± 0.63	0.11	19.67 ± 0.80	19.96 ± 0.80	20.23 ± 0.87	0.89

[1]CON = orally drenched 0.4 gal of water before (Exp. 1) or before and after transportation (Exp. 2); PRE = orally drenched with 0.4 gal of water containing 1.09 g of dry electrolyte/lb BW before transportation; POST = orally drenched with 1.5 L of water containing 1.09 g of dry electrolyte/lb BW after transportation

[2]L* = measure of darkness to lightness (greater value indicates a lighter color)

[3]a* = measure of redness (greater value indicates a redder color);

[4]b* = measure of yellowness (greater value indicates more yellow color).