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# Influence of Calcium Metabolism on Meat Tenderness in Heiferettes

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# Influence of Calcium Metabolism on Meat Tenderness in Heiferettes[1]

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## Summary

Forty beef-type heiferettes (initial BW=1016 ± 93 lb) were used to evaluate the influence of dietary calcium depletion followed by dietary repletion prior to slaughter on carcass and meat quality traits. Treatments were 1.) control - feed calcium diet for duration of trial (13 hd); 2.) calcium depleted 14 days followed by one feeding of replete diet 20 h prior to slaughter (13 hd); 3.) calcium depleted 14 days followed by two feedings of repleted diet 20 h and 44 h before harvest (14 hd). Heifers were sorted on condition and weight from a larger population of 280 head. Heiferettes were fed 56 d before the initiation of the treatments. Treatments were initiated 16 d prior to slaughter. No differences in ADG or F:G were observed during this time. At harvest, no differences were found for end weight, dressing percent, hot carcass weight, backfat, ribeye area, yield grade or marbling score. Measurements of tenderness were conducted using Warner Bratzler Shear force. No differences were observed with 39% of the carcasses classified as tough (greater than 5.0 lb of shear force).

## Introduction

Calcium is a macro-mineral that plays a key role as an intracellular second messenger for calpain activity. It is tightly regulated and under normal production scenarios remains between 8.5 and 10.3 mg/dl (Granner, 2000). Previous research has attempted to manipulate calcium levels by feeding pharmacological levels of Vitamin D which facilitates calcium binding protein synthesis. We have theorized that manipulation of Ca in the feedlot animal can be accomplished through dietary depletion-repletion. This is the same methodology used in the dairy industry (Green et al., 1981) to reduce the occurrence of milk fever (parturient paresis). Calcium is fed at relatively high levels in most feedlot finishing diets which minimizes the potential and success to manipulate Ca through the addition of Vitamin D. In a previous study conducted by Walsh et al. (2004), a dietary Ca depletion/repletion (CDR) approach was attempted to increase muscle Ca content at harvest and subsequently beef tenderness. The approach simply involved removing limestone from standard feedlot diets for 14 d pre-harvest and then returning limestone to the diet for the final feeding before harvest. The technique caused a substantial increase ($P < 0.01$) in serum Ca (9.3 vs. 11.9 mg/dl); an important first step to elevating intramuscular Ca. However, muscle Ca was only numerically higher due to CDR (37.3 vs. 38.6 µg/g). In an initial study, beef cuts from steers under the age of 18 months were evaluated to be very tender. In control cattle, aged (15 d) shear force values of longissimus dorsi, triceps brachii, and semimembranosus muscles were 6.2 lb, 5.8 lb, and 7.8 lb, respectively. In semimembranosus muscle aged 5 d, the shear force was reduced ($P < 0.05$) by CDR (9.4 kg vs. 8.0 kg). It was the objective of the current research project to utilize an older population of cattle that would theoretically have tough meat.

## Materials and Methods

Forty beef-type heiferettes were selected from a larger population of 280 head and hauled 90 miles to the SDSU Nutrition Unit on June 7, 2004. Cattle were weighed, tagged and implanted with Synovex-H during feedlot arrival processing. Cattle were randomly assigned to one of three dietary treatments: 1.) control - feed calcium diet for duration of trial (13 hd); 2.) - calcium depleted 14 days followed by one feeding of replete diet 20 h prior to slaughter (13 hd); 3.) calcium depleted 14 days followed by two feedings of repleted diet 20 h and 44 h before harvest (14 hd). Cattle were allotted to pen and adapted to a standard finishing diet (0.91% Ca; Table 1) by a series of three step up diets which depleted the level of hay in the diet (30%, 15%, and 0%) over a 12 d period.

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Harvest was targeted to optimize bodyweight and flesh for current markets (0.4" ribfat depth).

Fourteen days prior to harvest, dietary treatments were initiated by the removal of $CaCO_3$ from the supplement which reduced dietary Ca to 0.08% of the diet. At 20 h (1 feeding) and 44 h (2 feedings) prior to harvest, Ca was restored to the diet (repletion). During this time, control animals were continuously fed the 0.91% Ca diet. Blood levels of Ca were determined before harvest prior to loadout.

Standard carcass evaluations for determination of USDA Quality and Yield Grades were determined on carcasses chilled for 24 h. After grading, longissimus dorsi were removed from the carcass, sliced into a 1" thick steak and vacuum packaged for aging (7 days). After aging time, shear force was determined utilizing Werner Bratzler Shear Force.

The analysis of variance was appropriate for a completely random design study with repeated measures over time (aging). Means separations were accomplished using least square means.

### Results and Discussion

Performance parameters measured every 21 days, however variation in ADG and F:G was evident from period to period due to heifers within treatments calving. Thus, performance data reported in Table 2 was divided into two periods for the trial. Period 1 0-56 d represents the time on feed prior to the treatments being implemented and period 2 56 -72 d when the treatments were administered. As expected no differences in performance were observed between the three treatments as all cattle were consuming the same ration till day 56 of the trial. Feed efficiency tended to be poorer for cattle being fed one feeding of the calcium-repleted diet as ADG was 45% lower than the controls with similar values for DMI. Two heifers from treatment two calved within 35 and 2 days of the weigh period and were 9% and 55% below the average of the group for the next weigh period. Four heifers calved during the duration of the trial. Reduction in ADG from the time of calving to the next weigh period was on average 260% with an average window of 10 days from calving to the next weight period. The reduction in gain can be attributed to these heifers calving at or very near full term.

Carcass cutability data is reported in Table 3. Data was not obtained on one carcass as it was railed out due to an infected joint. Excessive trim occurred on this carcass, so HCW and DP data were removed from the dataset. No differences were found for shrunk dressing percent [HCW/(live wt. *.96)], HCW, rib fat, loin muscle area, or yield grade. Carcass did have adequate amounts of muscle on average to meet the required rib eye area needed to maintain yield grade. Two carcasses were calculated to be YG 4's and one YG 5.

Carcass quality data is presented in Table 4. No differences were detected for quality parameters measured. Cattle were mouthed prior to shipment to determine age. Average age for all cattle was 2.4 years. Average marbling score was Small$^{18}$ or Choice$^{-}$ for all cattle. Visual estimation of carcass maturity was quantified by trained university personal. Average bone, lean and overall maturity were $B^{18}$, $B^{28}$, and $B^{23}$. Forty-four percent of the carcasses were A maturity, 46% B maturity and 10 % C maturity which were classified has hard bones. Thirty-three percent of the population graded choice or better with 13% selects, 44% standards and 10% commercials.

No differences were observed for Warner Bratzler shear force. Shear force values less than 7.7 lbs are considered tender and greater than 11.1 lbs are considered tough. On average shear force values neared what would be considered tough at 10.8 lbs. Carcasses classified as tender were 20.5%, with 41.0% average, and 38.5 % tough.

Serum calcium levels were not different between treatments indicating our inability to elevate serum calcium via calcium depletion repletion in this particular trial.

In previous research (Walsh, 2004) depletion for 14 days followed by feeding normal levels 16 hours before harvest resulted in elevated blood serum calcium levels. In the present study, harvest time was greater from the time calcium was brought back to normal (20 hours after one feeding and 40 hours past the 2$^{nd}$ feeding treatment). Calcium levels may have peaked and equalized before slaughter. Additional research, concentrated on the time between calcium repletion after depletion and slaughter is necessary.

## Implications

In this study, diet depletion then repletion of calcium level in the diet was unable to elevate serum calcium levels to the level to improve tenderness.

The cattle population used in this study proved beneficial in producing the tougher meat, which was desired. However, differences in pregnancy and calving affected performance parameters measured.

## Literature Cited


Granner, D. K. 2000. Hormones that regulate calcium metabolism. In Harpers Biochemistry. R. K. Murry, K. K. Granner, P. A. Mayes, and V. W. Rodwell, ed. 25$^{th}$ Ed. McGraw-Hill, New York, NY.

Walsh, T. A. 2004. The influence of calcium metabolism on beef tenderness. M.S. Thesis, South Dakota State University.


## Tables

Table 1. Finishing diet on a dry matter basis

| | |
|---|---|
| High moisture ear corn | 44.0 |
| Whole shelled corn | 43.75 |
| Dried distillers grains | 8.00 |
| Supplement | 4.25 |
| | |
| $NE_m$, mcal/cwt | 88.7 |
| $NE_g$, mcal/cwt | 62.6 |
| Crude protein, % | 12.2 |
| Calcium, % | 0.612 |
| Phosphorus | 0.333 |

Table 2.  Performance

| | Control | Ca Repleted 1 Feeding | Ca Repleted 2 Feedings | SEM | P-value |
|---|---|---|---|---|---|
| n, (pens) | 2 | 2 | 2 | | |
| In weight., lb | 1007 | 994 | 1015 | 5.7 | 0.41 |
| Period 1 d 0-56 | | | | | |
| Body weight, lb | 1175 | 1177 | 1196 | 11.9 | 0.76 |
| ADG, lb | 3.0 | 3.3 | 3.2 | 0.17 | 0.80 |
| DMI, lb | 23.1 | 23.4 | 24.7 | 2.5 | 0.27 |
| F:G | 7.7 | 7.2 | 7.8 | 0.38 | 0.81 |
| Period 2 d 56-72 | | | | | |
| Body weight, lb | 1232 | 1207 | 1249 | 17.6 | 0.67 |
| ADG, lb | 3.5 | 1.9 | 3.3 | 0.42 | 0.35 |
| DMI, lb | 22.8 | 22.7 | 23.5 | 1.0 | 0.93 |
| F:G | 6.7 | 12.1 | 7.5 | 0.60 | 0.07 |
| Cumulative, d 0 - 72 | | | | | |
| Body weight, lb | 1232 | 1207 | 1249 | 17.6 | 0.67 |
| ADG, lb | 3.1 | 3.0 | 3.2 | 0.21 | 0.87 |
| DMI, lb | 23.1 | 23.3 | 24.4 | 0.41 | 0.45 |
| F:G | 7.4 | 7.9 | 7.7 | 0.43 | 0.92 |

Table 3.  Carcass cutability data

| | Control | Ca Repleted 1 Feeding | Ca Repleted 2 Feedings | SEM | P-value |
|---|---|---|---|---|---|
| n, (head) | 13 | 13 | 13 | | |
| Harvest wt., lb | 1232 | 1207 | 1248 | 17.6 | 0.67 |
| Dressing, %[a] | 62.3 | 62.2 | 62.5 | 0.39 | 0.99 |
| HCW, lb | 737 | 723 | 749 | 12.35 | 0.74 |
| Ribfat, in. | 0.48 | 0.42 | 0.49 | 0.10 | 0.76 |
| LMA, $in.^2$ | 12.6 | 13.1 | 12.1 | 0.19 | 0.19 |
| Yield Grade | 3.0 | 2.6 | 3.2 | 0.13 | 0.27 |

[a]Shrunk dressing % = HCW/(Harvest weight x 0.96)

Table 4. Carcass quality data

| | Control | Ca Repleted 1 Feeding | Ca Repleted 2 Feedings | SEM | P-value |
|---|---|---|---|---|---|
| n, (head) | 13 | 13 | 13 | | |
| In Wt., lb | 1007 | 994 | 1015 | 5.7 | 0.41 |
| Marbling[a] | 518 | 514 | 517 | 15.1 | 0.98 |
| Dental age, yrs[b] | 2.7 | 2.3 | 2.4 | 0.11 | 0.33 |
| Bone maturity[c] | 213 | 222 | 218 | 10.0 | 0.72 |
| Lean maturity[d] | 226 | 222 | 235 | 8.7 | 0.94 |
| Overall maturity[e] | 218 | 226 | 225 | 8.5 | 0.84 |
| Grade, No. of Head / % | | | | | |
| Prime | 1 / 7.7 | 0 / 0.0 | 0 / 0.0 | | |
| Upper 2/3 Choice | 0 / 0.0 | 1 / 7.7 | 1 / 7.7 | | |
| Choice- | 2 / 15.4 | 3 / 23.1 | 5 / 38.5 | | |
| Select | 2 / 15.4 | 2 / 15.4 | 1 / 7.7 | | |
| Standard | 7 / 53.6 | 5 / 38.5 | 5 / 38.5 | | |
| Commercial | 1 / 7.7 | 2 / 15.4 | 1 / 7.7 | | |
| Shearforce[f] | 10.6 | 10.6 | 11.2 | 0.57 | 0.21 |
| Shearforce category[g] | | | | | |
| Tender | 3 | 3 | 2 | | |
| Average | 5 | 6 | 5 | | |
| Tough | 5 | 6 | 5 | | |
| Serum Calcium | 98.0 | 95.7 | 96.5 | 0.74 | 0.64 |

[a] 500 = small°.
[b]determined by trained individual at feedyard.
[c]100 = A maturity; 200 = B maturity.
[d]100 = A maturity; 200 = B maturity.
[e]100 = A maturity; 200 = B maturity.
[f]shear force determined by Warner Bratzler shear force, lb.
[g]Tender = < 3.5 lb; average 3.6-4.9 lb; tough > 5.0 lb.