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Mineral Composition of Beef Cattle Carcasses

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Summary

Mineral retention was measured in 76 beef steers. Cattle were grown at different rates of gain and then finished on a common diet. Calcium and P retention were not affected by treatment and were similar between the growing and finishing periods averaging 4.2 g P and 10.8 g Ca /100 g protein gain across both experiments. As ADG during the growing period was decreased, K, Mg, and S mineral retention during the finishing period were increased. Expressing mineral retention as g/100 g protein gain reduced variation due to animal size and ADG and suggests that current NRC predictions are accurate.

Introduction

Mineral requirements for growing beef cattle are not well understood, one component of which is requirements for gain. Very few carcasses have been analyzed to determine mineral retention, with Ca and P being the most commonly analyzed minerals. Other minerals such as K, Mg, and S are very rarely measured or reported in serial slaughter trials. Retention of minerals is important in order to identify mineral requirements at different rates of gain, in addition to maintenance requirements. Retention is also used to calculate mineral excretion values, with excretion being predicted from the difference between intake and retention. Developing better estimates of mineral retention allows for better estimates of manure nutrient values, and thus better recommendations for manure application rates. This trial utilized existing serial slaughter samples in order to calculate mineral retention of beef cattle harvested at various time points and grown in several different production systems.

Procedure

Seventy-six beef cattle were slaughtered at Oklahoma State University, and whole carcasses were divided into carcass, offal, and viscera. These samples were ground and frozen and then analyzed for Ca, P, K, Mg, and S by Ward Laboratory (Kearney, Neb.). Sample analysis included acid digestion of all organic matter, followed by mineral analysis using Inductively Coupled Plasma-Atomic Emission Spectroscopy. Total offal included blood, head, hide, feet, ears, internal organs, and trim. Visceral organs included reticulo-rumen, omasum, abomasum, small intestine, cecum, large intestine, pancreas, spleen, omental and mesenteric fat. Weights of total carcass, visceral organs, and offal were recorded. Cattle were on two separate experiments and were harvested at various time points after being grown in several different production systems.

Experiment (Exp.) 1 (*Journal of Animal Science,* 82:262) utilized 30 British crossbred steers wintered at three different levels of gain and then finished on a common diet. Cattle grazed wheat pasture to gain 2.89 lb/day (high gain wheat; HGW) or 1.19 lb/day (low gain wheat; LGW), or grazed dormant native range supplemented with 2 lb of cottonseed meal each day and gaining 0.35 lb/day (native range; NR). At the end of the winter grazing season, four steers were slaughtered from each treatment group. The remaining steers were placed on a common finishing diet and six additional steers from each treatment were slaughtered at approximately 0.6 inches of backfat. Cattle from HGW reached 0.6 inches of backfat after 89 days on feed, LGW cattle after 116 days on feed, and NR cattle after 163 days on feed. Cattle performance during the growing and finishing phases is shown in Table 1; live performance measurements were taken on 48 steers, including the 30 steers used for serial slaughter.

Experiment 2 (*Journal of Animal Science* 88:1564) utilized 46 British crossbred steers grown at different rates and on different diets. Four steers were slaughtered at initiation of the trial to determine initial carcass composition. Remaining cattle were split between calf-feds placed directly into the feedlot (CF) and three growing treatments: grazing wheat pasture

Table 1. Cattle performance during the growing and finishing phases of Experiment 1[1].

	HGW[2]	LGW	NR	SEM	*P*-value
Growing phase					
Days	120	120	120	—	—
ADG, lb	2.89	1.19	0.35	—	—
12th-rib fat, in	0.46[a]	0.10[b]	0.004[b]	0.04	< 0.05
HCW, lb	522[a]	381[b]	302[c]	10.8	< 0.05
Finishing phase					
Days	89	116	163	—	—
ADG, lb	3.94	3.97	4.01	0.13	0.43
12th-rib fat, in	0.64	0.62	0.59	0.07	> 0.05
HCW, lb	754[a]	701[b]	725[ab]	8.2	< 0.05

[1]All data measuring cattle performance collected by Oklahoma State University and published in *Journal of Animal Science,* 82:262.
[2]Treatments were due to diet fed during the growing phase and included cattle grazing wheat pasture at a high rate of gain (HGW), cattle grazing wheat pasture at a low rate of gain (LGW), and cattle grazing dormant native range pasture (NR). All cattle were finished on a common diet.
[a-c]Means within a row without a common superscript differ ($P < 0.05$).

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Table 2. Cattle performance during the growing and finishing phases of Experiment 2[1].

	WP[2]	SF	PF	CF	SEM	*P*-value
Growing phase						
Days	112	112	112	—	—	—
ADG, lb	2.54[a]	2.43[b]	2.60[a]	—	0.04	0.01
12th-rib fat, in	0.17	0.20	0.23	—	0.03	0.32
HCW, lb	489[ab]	467[a]	522[b]	—	17.2	0.10
Finishing phase						
Days	123	104	104	196	—	—
ADG, lb	3.62[a]	4.45[b]	4.08[c]	3.59[a]	0.09	< 0.01
12th-rib fat, in	0.53[a]	0.50[a]	0.49[a]	0.64[b]	0.019	< 0.01
HCW, lb	851	836	829	818	9.7	0.12

[1]All data measuring cattle performance collected by Oklahoma State University and published in *Journal of Animal Science,* 88:1564.
[2]Treatments were due to diet fed during the growing phase and included grazing wheat pasture (WP), a sorghum silage based diet (SF), program fed a high concentrate diet (PF), or placed directly into the feedlot as calf-feds (CF). All cattle were finished on a common diet.
[a-c]Means within a row without a common superscript differ ($P < 0.05$).

Table 3. Mineral retention within the empty body of beef cattle during the finishing phase while on a common high concentrate diet (Experiment 1).

	HGW[1]	LGW	NR	SEM	*P*-value
Calcium					
g/day	31.8	58.9	24.6	15.38	0.09
g/kg EBW gain	17.1	30.4	14.9	8.06	0.15
g/100 g protein gain	9.8	17.3	13.1	6.06	0.48
Phosphorus					
g/day	14.8	9.8	10.2	2.70	0.15
g/kg EBW gain	8.0	5.0	6.2	1.48	0.17
g/100 g protein gain	4.1	3.2	5.1	1.32	0.39
Potassium					
g/day	1.6[b]	4.9[a]	5.2[a]	0.821	< 0.01
g/kg EBW gain	0.9[b]	2.5[a]	3.2[a]	0.494	< 0.01
g/100 g protein gain	0.5[b]	1.4[ab]	2.9[a]	0.746	0.02
Magnesium					
g/day	-0.2[b]	1.3[a]	0.7[a]	0.330	< 0.01
g/kg EBW gain	-0.1[b]	0.7[a]	0.5[a]	0.176	< 0.01
g/100 g protein gain	-0.1[b]	0.4[a]	0.4[a]	0.141	0.01
Sulfur					
g/day	1.2[b]	4.1[a]	3.6[a]	0.546	< 0.01
g/kg EBW gain	0.6[b]	2.1[a]	2.2[a]	0.308	< 0.01
g/100 g protein gain	0.3[b]	1.2[a]	1.9[a]	0.365	< 0.01

[1]Treatments were due to diet fed during the growing phase and included cattle grazing wheat pasture at a high rate of gain (HGW), cattle grazing wheat pasture at a low rate of gain (LGW), and cattle grazing dormant native range pasture (NR). All cattle were finished on a common diet; mineral retention was calculated for the finishing phase.
[a-c]Means within a row without a common superscript differ ($P < 0.05$).

(WP), fed a sorghum silage growing diet (SF), or program fed (PF) a high concentrate (steam-flaked corn) diet to gain at a similar rate as SF cattle. At the end of 112 days, six steers from each of the three growing diets were slaughtered, and remaining cattle were placed onto the finishing diet CF cattle were already on. At approximately 0.5 inches of backfat, six calves from each of the four treatments were slaughtered. Cattle on the CF treatment were on feed for 196 days. After the 112 day growing phase, cattle on WP were on feed for 123 days, SF and PF for 104 days. Cattle performance during the growing and finishing phases is shown in Table 2; live performance measurements were taken on 260 steers, including the 46 steers used for serial slaughter.

Mineral retention within the body was calculated as the difference between mineral composition at slaughter and predicted mineral composition at day 0. Mineral composition at day 0 was predicted from body composition of steers harvested at day 0 multiplied by live weight of individual animals at day 0. For Exp. 1, mineral retention was calculated for each treatment during the finishing period. In Exp. 2, mineral retention was calculated for the growing and finishing periods separately for each treatment except CF, which only consisted of a finishing period. Mineral retention was then expressed as grams per day, grams per kg empty body weight (EBW) gain, and grams per 100 g protein gain. In live animals EBW is calculated as full BW multiplied by 0.855; however, for these trials EBW was measured by weighing the whole carcass after the contents of the gastrointestinal tract had been removed.

For statistical analysis in Exp. 1, mineral retention among treatments was compared with individual animal as the experimental unit. In Exp. 2, mineral retention within the growing phase, within the finishing phase, and overall mineral retention were compared by treatment using an F-test with individual animal as the experimental unit. Because all comparisons within each of the phases were non-significant ($P \geq 0.19$) only mineral retention for the growing and finishing phases combined is shown. Mineral retention within the growing phase was also compared to retention during the finishing phase, but was found to be non-significant ($P \geq 0.28$). For both trials all differences were declared significant at $P < 0.05$.

Results

The NRC currently expresses P and Ca retention as g/100 g protein gain. In the current trials, expressing mineral retention on a protein gain basis reduced variation due to diet, rate of gain, and days on feed.

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Experiment 1

Mineral retention was calculated for the finishing period following three different diets being fed during the growing phase. There were no differences due to treatment for P or Ca retention ($P \geq 0.15$ and $P \geq 0.09$, respectively) expressed as g/day, g/kg EBW gain, or g/100 g protein gain (Table 3). Retention of P and Ca averaged 4.1 g P/100 g protein gain and 13.4 g Ca/100 g protein gain, respectively, over all three treatments. Mineral retention was significantly different among treatments for K, Mg, and S ($P < 0.02$) during finishing. Potassium, Mg, and S retention were greatest for NR and LGW cattle and least for HGW cattle. This indicates an increase in mineral retention during the finishing period because diet quality and ADG during the growing period were reduced.

Experiment 2

Mineral retention was calculated for the growing and finishing periods separately for each treatment, except CF, which consisted only of a finishing period. There were no differences due to treatment for combined mineral retention in the growing and finishing periods and no differences between the growing and finishing periods for P ($P \geq 0.36$), Ca ($P \geq 0.23$), K ($P \geq 0.38$), Mg ($P \geq 0.12$), or S ($P \geq 0.20$) retention when expressed as g/kg EBW gain, or g/100 g protein gain (Table 4). Retention of Mg was impacted by treatment when expressed as g/day ($P = 0.05$). Phosphorus retention over the growing and finishing periods combined averaged 4.3 g P/100 g protein gain for all four treatments. Calcium, K, Mg, and S retention averaged 8.2, 1.3, 0.3, and 1.1 g/100 g protein gain for all four treatments, respectively. Cattle were on different diets during the growing period, but small differences in ADG during the growing period (< 7%; $P < 0.01$) resulted in no differences in mineral retention due to treatment.

Table 4. Mineral retention within the empty body of beef cattle during the growing and finishing phases combined (Experiment 2).

	WP[1]	SF	PF	CF	SEM	*P*-value[3]
Calcium[2]						
g/day	12.5	21.1	17.5	12.9	5.34	0.34
g/kg EBW gain	15.2	26.3	20.0	13.9	6.34	0.23
g/100 g protein gain	7.2	10.7	8.3	6.7	3.03	0.56
Phosphorus						
g/day	7.0	10.3	8.9	6.9	2.55	0.50
g/kg EBW gain	8.8	12.9	10.2	7.5	3.05	0.36
g/100 g protein gain	4.0	5.3	4.2	3.6	1.44	0.70
Potassium						
g/day	2.5	2.4	2.9	2.4	0.514	0.73
g/kg EBW gain	3.5	3.0	3.2	2.5	0.785	0.61
g/100 g protein gain	1.3	1.2	1.3	1.2	0.220	0.88
Magnesium						
g/day	0.5	0.6	0.8	0.5	0.095	0.05
g/kg EBW gain	0.7	0.8	0.9	0.5	0.144	0.12
g/100 g protein gain	0.3	0.3	0.4	0.3	0.056	0.37
Sulfur						
g/day	2.1	2.0	2.4	2.2	0.222	0.34
g/kg EBW gain	2.8	2.5	2.7	2.3	0.402	0.56
g/100 g protein gain	1.1	1.0	1.1	1.2	0.112	0.50

[1]Treatments were due to diet fed during the growing phase and included grazing wheat pasture (WP), a sorghum silage based diet (SF), program fed a high concentrate diet (PF), or placed directly into the feedlot as calf-feds (CF). All cattle were finished on a common diet.
[2]Mineral retention was calculated separately for the growing and finishing phases. Combined mineral retention for the growing and finishing phases is shown, except for the CF treatment which consisted only of a finishing phase.
[3]*P*-values shown compare mineral retention of treatments for the combined growing and finishing phases. There were no differences in mineral retention due to treatment during the growing phase ($P \geq 0.19$) or comparing the growing and finishing phases ($P \geq 0.28$).

The current NRC (2000) reports P retention as 3.9 g P/100 g protein gain and Ca retention as 7.1 g Ca/100 g protein gain. These values are calculated from serial harvest data and represent retention within 132 dairy cattle at various stages of growth. Data from the current two trials complement these data, with similar overall values, 4.2 g P/100 g protein gain and 10.8 g Ca/100 g protein gain, suggesting little change in mineral retention within cattle or in the methods used to measure mineral retention. Variation among animals, measurement techniques, or a combination of both appears to be greater than variation due to diet as no differences were detected by treatment for P and Ca retention. Retention of other minerals (K, Mg, and S) can be impacted by diet quality and ADG during the growing period, as shown in Exp. 1. Expressing mineral retention relative to rate of gain equalizes changes in retention due to rate of gain and decreases variation due to treatment. These data suggest that the current method of expressing mineral retention as g/100 g protein gain used by the NRC is the most appropriate.

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