2015

Mineral Composition of Serial Slaughter Holstein Carcasses

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Summary

Carcasses of 115 Holstein steers were divided into lean, bone, internal cavity, hide, and fat tissues for analysis of P, Ca, K, Mg, and S retention. Every 28 days, five steers from each of two treatments, fed Zilmax for 20 days prior to harvest or not fed Zilmax, were harvested. There were no differences due to treatment or days on feed when mineral retention was expressed as g/100 g of protein gain. Expressing mineral retention relative to protein gain reduced variation due to rate of gain and animal size.

Introduction

Mineral requirements for beef cattle are composed of maintenance and gain requirements and mineral retention relative to gain has not been widely researched. Some data are available on P and Ca retention, predominately in Holstein cattle. Very few, if any, data have been published on K, Mg, and S retention within the whole body of cattle. Mineral retention data are used to calculate mineral requirements of growing cattle for both maintenance and gain and for calculating mineral excretion in manure. In order to accurately predict mineral excretion from cattle and make valuable recommendations on mineral availability within manure, knowing mineral retention is critical. This trial utilized existing serial slaughter samples in order to calculate mineral retention of Holstein steers harvested at 28 day intervals over a 308 day feeding period.

Procedure

One hundred fifteen Holstein steers were utilized in a serial harvest trial conducted by the Beef Carcass Research Center, West Texas A&M University, Canyon, Tex. Five steers were harvested after 226 days on feed, which was designated day 0, or initiation of the trial. Two treatments were imposed on the remaining cattle, a control group (CON) and cattle fed Zilmax (8.3 mg/kg diet DM) for 20 days followed by a three day withdrawal, immediately prior to harvest (ZH). All cattle were fed in a GrowSafe system (GrowSafe Systems Ltd., Airdrie, AB, Canada) in open lot pens. Cattle were harvested every 28 days starting on June 25, 2012 (initial slaughter), with five steers per treatment in every slaughter group after the initial harvest. There were 12 total harvest points including the initial slaughter ranging from day 0 to day 308; the seventh slaughter group (day 168) was omitted from calculations and analysis due to outliers in the data (more than three SD away from the mean). Slaughter groups 1 through 7 were harvested at the Beef Carcass Research Center. At this point steers were too big for the facility to handle, and slaughter groups 8 through 12 were harvested at a nearby commercial facility. Whole carcasses were divided into lean, bone, internal cavity (liver, gallbladder, pancreas, bladder, lungs, heart, spleen, empty stomach, empty intestine, and kidneys), hide, and fat trim components. Each tissue type was weighed and sampled. These samples were ground, frozen, and analyzed for Ca, P, K, Mg, and S by a commercial laboratory (Servi-Tech, Amarillo, Tex.). Samples were acid digested to remove all organic matter and analyzed for minerals using Inductively Coupled Plasma-Atomic Emission Spectroscopy.

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 the live weight of individual animals at day 0. Due to the short interval between harvest points (28 days) and no differences in P and Ca composition of the bone portion of the body over time ($P \geq 0.89$), initial P and Ca composition of the bone fraction was predicted using each steer's mineral composition instead of the average of the day 0 harvested cattle. With no changes over time in bone Ca and P content, individual steer data better predicted day 0 compositions than using day 0 data to predict individual steer mineral content. This method was not appropriate for other minerals or other tissues as these did have changes in mineral content over time ($P < 0.10$). Mineral retention was calculated for each individual tissue and then summed for statistical analysis on an empty body weight (EBW) basis. In live animals EBW is calculated as full BW multiplied by 0.855; however, in this serial slaughter trial EBW was measured by weighing the whole carcass after the gastrointestinal tract contents had been removed. Mineral retention was expressed as grams per day, grams per kg EBW gain, and grams per 100 g protein gain.

For statistical analysis, fixed effects included treatment and days on feed with individual animal as the experimental unit. The treatment by days on feed interaction was significant for K retention ($P < 0.01$) but not for other minerals ($P \geq 0.16$). Linear, quadratic, and cubic contrasts over time were also analyzed.

Results

Weights of all tissues increased linearly over time ($P < 0.01$) with increasing days on feed (Figure 1). As a % of EBW, lean, bone, and hide tissues decreased linearly over time ($P < 0.01$) while internal cavity and fat tissues linearly increased over time ($P < 0.01$). Fat trim increased from 2.9 to 11.6% of EBW while lean tissue decreased from 47.2 to 37.7% of EBW

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from day 0 to day 308. Cattle on ZH had a greater percent of EBW as lean tissue ($P < 0.01$) and less bone, internal cavity, and hide ($P < 0.01$). Fat trim, as a % of EBW, was not significantly different between treatments ($P = 0.42$).

Mineral composition of tissues, with the exception of Ca and P content of bone, fluctuated over time. As a % of DM, P content of lean, hide, internal cavity, and fat tissues decreased linearly over time ($P < 0.01$). Linear decreases in Ca, K, and Mg content were observed in lean and hide tissues ($P \leq 0.02$). Sulfur content of the hide increased linearly over time ($P < 0.01$) presumably due to accumulation of sulfur containing amino acids in the hair coat of animals, especially evident as cattle were housed outdoors with initial slaughter in June and subsequent slaughter groups every 28 days until the following April. Sulfur content of all other tissues decreased linearly over time ($P < 0.01$). Differences in mineral content due to treatment were minimal, except ZH lean tissue had greater concentrations of P, K, and Mg ($P < 0.05$) and ZH internal cavity tissue had greater P content ($P < 0.01$) than CON. Averaged across treatment and days on feed, 92% of P and 99% of Ca present in the body was in the bone.

Calculating mineral retention relative to protein gain (g/100 g protein gain) resulted in no statistical differences due to treatment or days on feed ($P > 0.10$). Figures 2 to 6 show P, Ca, K, Mg, and S retention, as both g/kg EBW gain and g/100 g of protein gain, across days on feed by treatment. Mineral retention as g/kg EBW gain is shown for individual tissues while g/100 g protein gain is shown as retention within the entire body. There were no differences due to treatment for P retention ($P \geq 0.12$) with a linear decrease over days on feed ($P < 0.01$) when expressed as g/kg EBW gain. However, when expressed relative to protein gain there were no differences over time ($P \geq 0.15$; Figure 2). There were no differences in Ca retention due to treatment ($P \geq 0.39$) or days on feed ($P \geq 0.11$) when expressed relative to protein gain; when expressed on an EBW gain basis CON cattle had greater

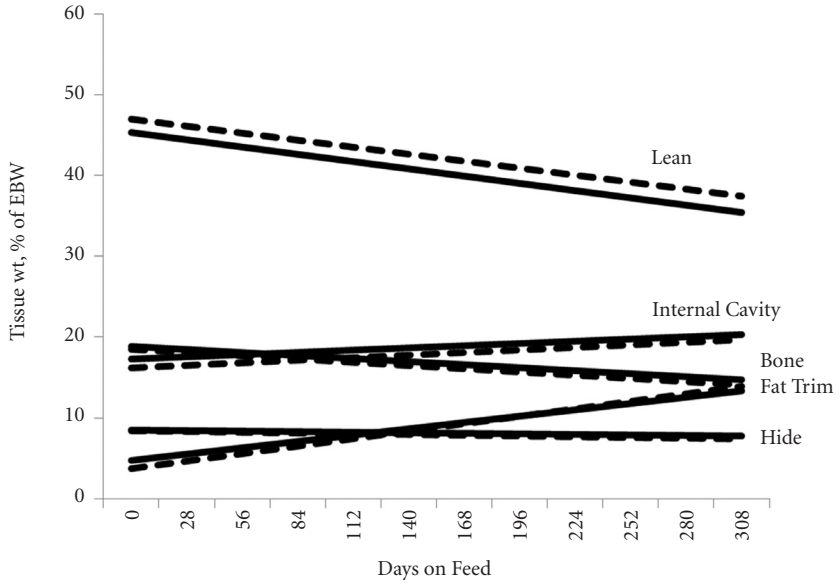

Figure 1. Weight of individual tissues of serially harvested Holstein Steers, expressed as a percent of empty body weight (EBW). Changes in tissue weight are shown across days on feed and by treatment. Treatments included control cattle (—) and cattle fed Zilmax for 20 days prior to harvest (---). Lean, bone, internal cavity, and hide differed by treatment ($P \leq 0.01$); fat trim did not differ by treatment ($P = 0.42$). Lean, bone and hide linearly decreased over days on feed while internal cavity and fat trim linearly increased ($P < 0.01$).

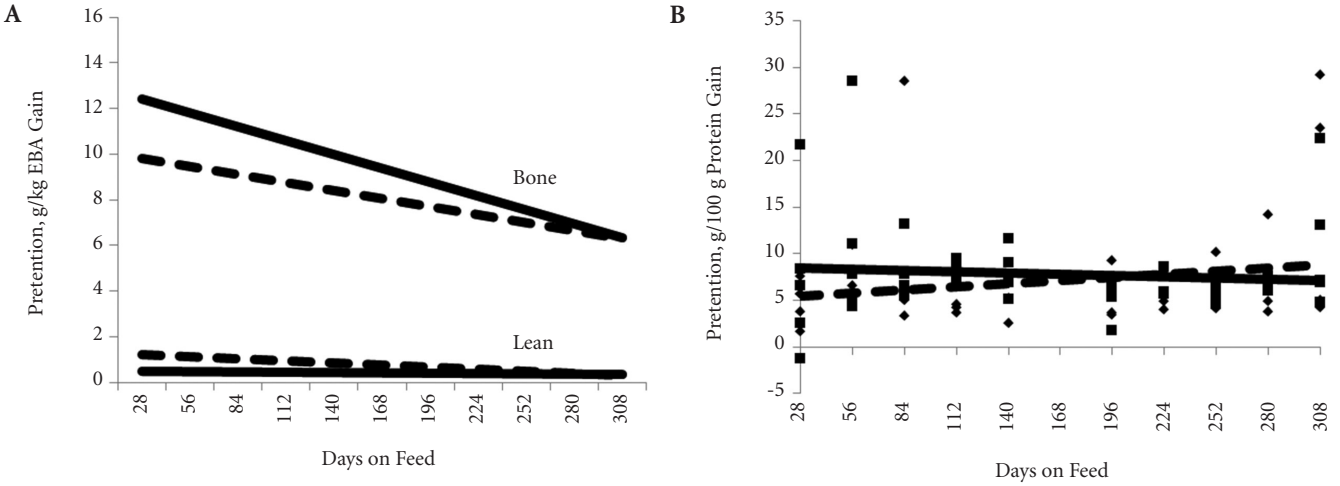

Figure 2. Phosphorus retention of serially harvested Holstein steers, expressed as g/kg empty body weight (EBW) gain or g/100 g protein gain. Changes in P retention are shown across days on feed and by treatment. Treatments included control cattle (—) and cattle fed Zilmax for 20 days prior to harvest (---).
A. Retention relative to EBW gain is broken down into bone and lean tissues, retention within hide, internal cavity, and fat were minor, less than 0.4 g. No differences were observed by treatment ($P \geq 0.12$) with linear decreases across days on feed ($P < 0.01$).
B. Retention relative to protein gain is shown for all tissues summed together. Individual animals are represented by points, square denote control cattle and diamonds denote Zilmax fed cattle. There were no differences due to treatment ($P \geq 0.52$) or days on feed ($P \geq 0.15$).

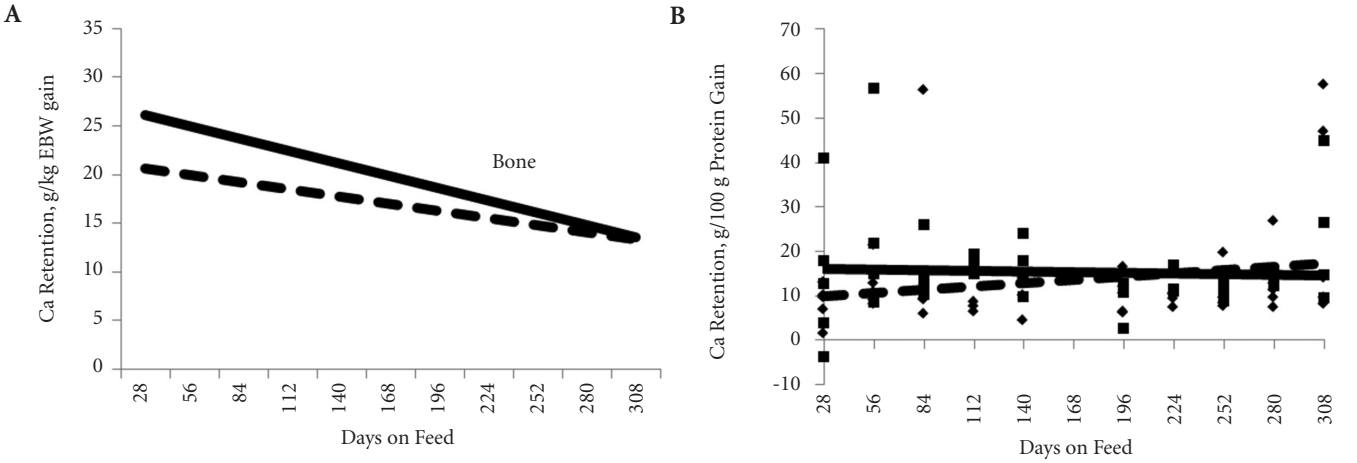

Figure 3. Calcium retention of serially harvested Holstein steers, expressed as g/kg empty body weight (EBW) gain or g/100 g protein gain. Changes in Ca retention are shown across days on feed and by treatment. Treatments included control cattle (—) and cattle fed Zilmax for 20 days prior to harvest (---).
A. Retention relative to EBW gain is shown only for bone tissue, which accounted for 99% of total body Ca retention. Control cattle had greater Ca retention ($P = 0.02$) than Zilmax fed cattle; Ca retention for both treatments linearly decreased across days on feed ($P < 0.01$).
B. Retention relative to protein gain is shown for all tissues summer together. Individual animals are represented by points, square denote control cattle and diamonds denote Zilmax fed cattle. There were no differences due to treatment ($P \geq 0.39$) or days on feed ($P \geq 0.11$).

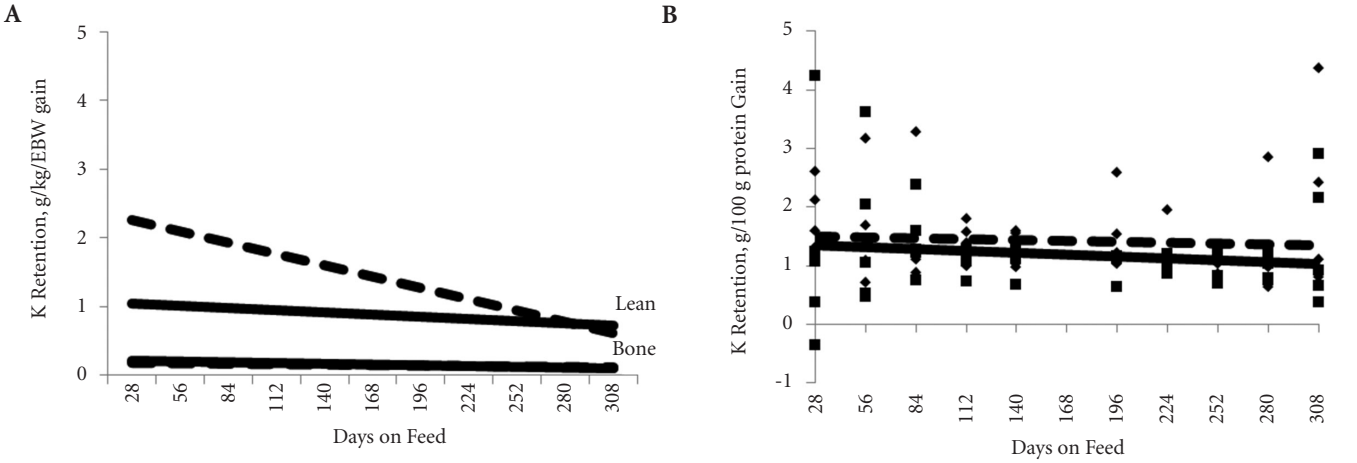

Figure 4. Potassium retention of serially harvested Holstein steers, expressed as g/kg empty body weight (EBW) gain or g/100 g protein gain. Changes in K retention are shown across days on feed and by treatment. Treatments included control cattle (CT; —) and cattle fed Zilmax for 20 days prior to harvest (ZH; ---).
A. Retention relative to EBW gain is broken down into lean and bone tissues. Retention within the lean tissue accounted for 62 and 72% of total body K retention for CT and ZH, respectively. Retention of K was greater for ZH cattle ($P < 0.01$) with linear decreases across days on feed ($P < 0.02$) for both treatments. The interaction between treatment and days on feed was significant ($P < 0.01$) with ZH cattle having greater decreases in K retention over time compared to CT cattle.
B. Retention relative to protein gain is shown for all tissues summed together. Individual animals are represented by points, squares denote control cattle and diamonds denote Zilmax fed cattle. There were no differences due to treatment ($P \geq 0.14$) or days on feed ($P \geq 0.60$).

Ca retention ($P = 0.02$) with both treatments linearly decreasing across days on feed ($P < 0.01$; Figure 3). Potassium retention was greater for ZH cattle ($P < 0.01$) when expressed as g/kg EBW gain with retention in both treatments linearly decreasing over time ($P < 0.01$; Figure 4). There were no differences in K retention due to treatment ($P \geq 0.14$) or days on feed ($P \geq 0.60$) when expressed relative to protein gain. Retention of Mg did not differ by treatment ($P \geq 0.64$) and decreased linearly across days on feed when expressed relative to EBW gain ($P < 0.01$), but was not different across days on feed when expressed relative to protein gain ($P \geq 0.34$; Figure 5). Retention of S did not differ by treatment or days on feed when expressed relative to EBW gain or protein gain ($P \geq 0.21$; Figure 6).

When mineral retention was expressed as g/day or g/kg EBW gain, there were statistical differences ($P \leq 0.02$) across days on feed for P, Ca, K, Mg, and S, mostly due to changes in tissue weights. There were no differences in P, Mg, and S retention expressed as g/day or g/kg EBW gain due to treatment ($P \geq 0.09$). Differences in K and Ca retention due to treatment were largely due to differences in amount of lean tissue, with ZH cattle having a greater percent of EBW as lean, 41.8% compared to 39.7% of EBW for CON. Lean tissue averaged 0.82% K for CON and 0.87% K for ZH ($P = 0.04$). The bone fraction was a larger percent of EBW for CON cattle, leading to greater Ca retention in CON cattle.

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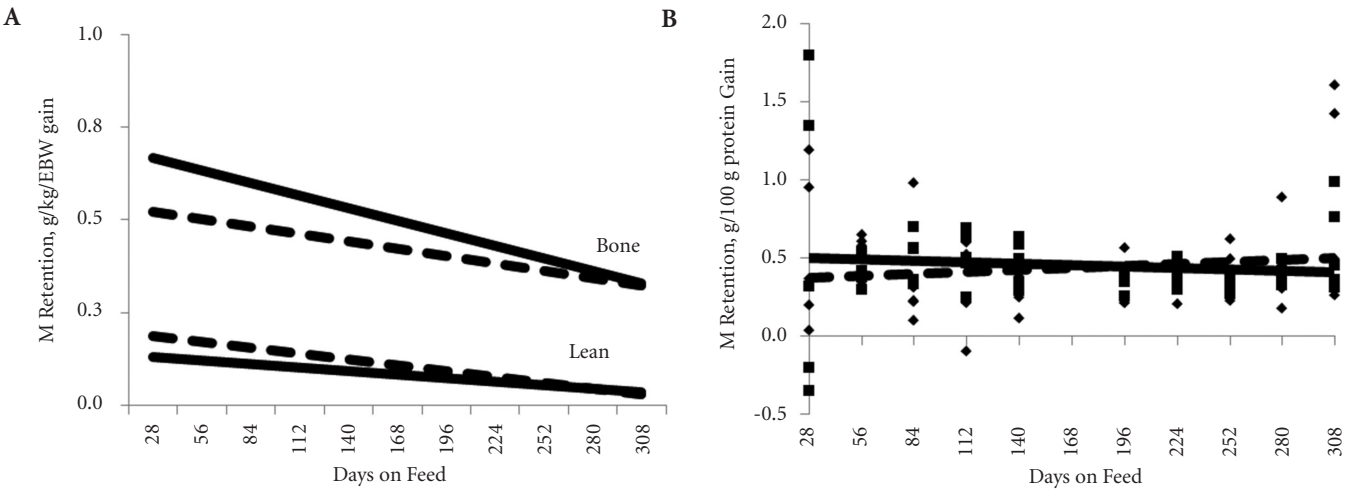

Figure 5. Magnesium retention of serially harvested Holstein steers, expressed as g/kg empty body weight (EBW) gain or g/100 g protein gain. Changes in Mg retention are shown across days on feed and by treatment. Treatments included control cattle (—) and cattle fed Zilmax for 20 days prior to harvest (---).
A. Retention relative to EBW gain is broken down into bone and lean tissues. These 2 tissues combined accounted for 94% of Mg retention within the entire body. No difference were observed by treatment ($P \geq 0.64$) with linear decreases across days on feed ($P < 0.01$).
B. Retention relative to protein gain is shown for all tissues summed together. Individual animals are represented by points, squares denote control cattle and diamonds denote Zilmax fed cattle. There were no differences due to treatment ($P \geq 0.82$) or days on feed ($P \geq 0.34$).

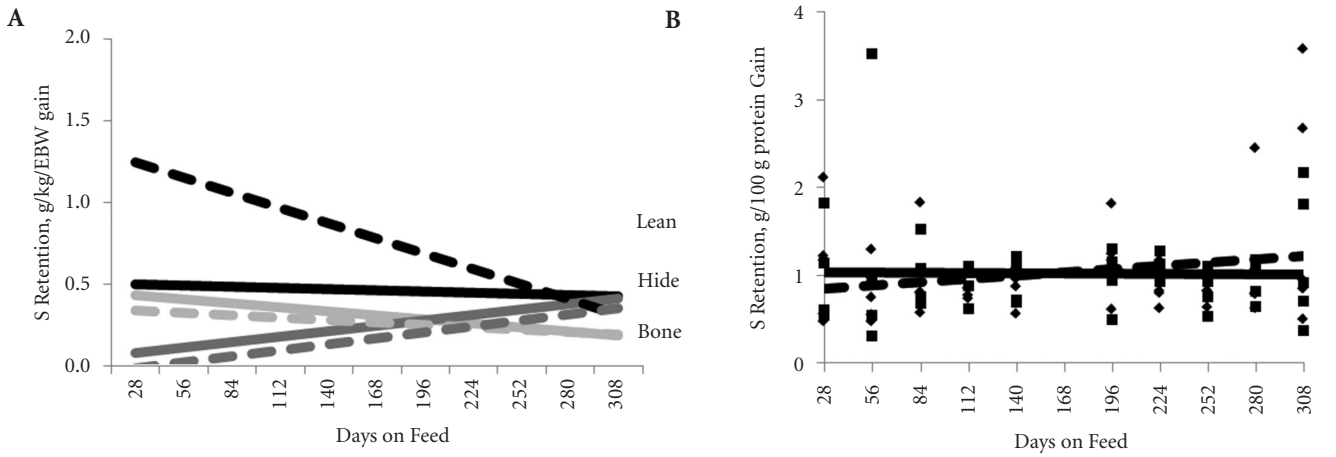

Figure 6. Sulfur retention of serially harvested Holstein steers, expressed as g/kg empty body weight (EBW) gain or g/100 g protein gain. Changes in S retention are shown across days on feed and by treatment. Treatments included control cattle (—) and cattle fed Zilmax for 20 days prior to harvest (---).
A. Retention relative to EBW gain is broken down into lean (black), hide (dark gray), and bone (light gray) tissues. Together these 3 tissues repretned 85% of S retention wtihin the entire body. No differences were observed by treatment ($P \geq 0.21$) or days on feed ($P < 0.31$).
B. Retention relative to protein gain is shown for all tissues summed together. Individual animals are represented by points, squares denote control cattle and diamonds denote Zilmax fed cattle. There were no differences due to treatment ($P \geq 0.90$) or days on feed ($P \geq 0.57$).

Expressing mineral retention relative to protein gain resulted in no statistical differences due to treatment or days on feed ($P \geq 0.11$), thus most of the variation in mineral retention was due to differences in rate and type of gain. Retention of P, Ca, K, Mg, and S averaged 7.5, 14.4, 1.3, 0.5, and 1.0 g/100 g of protein gain respectively. The current NRC (2000) reports P retention as 3.9 g/100 g protein gain and Ca retention as 7.1 g /100 g protein gain. These values are based on data from the 1940s, primarily measured in Holstein cows. Differences between trials may be due to differences in age and gender of cattle measured, diets fed, or methods used to measure mineral retention. Retention of Ca and P in the current trial with Holstein cattle was higher than retention measured in beef cattle (*2015 Nebraska Beef Cattle Report,* pp. 108-110). This is rational as a majority of both Ca and P is found in the skeleton and dairy breeds have a lower ratio of lean to bone (<3.4) compared to beef cattle (>3.6). Values for K, Mg, and S retention are not widely available for comparison.

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