1.84 hr.; $P<0.01$). We conclude that feeding HC can produce changes in rumen fermentation in Y and O heifers, but the magnitude of these changes can be reduced by restricting intake.

Key Words: Dairy heifers, Forage:concentrate, Rumen fermentation

598 The effects of restricted feeding high concentrate or high forage rations on nutrient digestibility and nitrogen utilization in dairy heifers. G. I. Zanton*, A. J. Heinrichs, and E. F. Wheeler, *The Pennsylvania State University*, *University Park*.

The objective of this experiment was to evaluate nutrient digestibility and nitrogen utilization in dairy heifers fed a high concentrate (**HC**) or a high forage (**HF**) ration at two different ages. The experiment was designed as a split plot design with Young (**Y**; 313 ± 4d; 263 ± 6kg) and Old (**O**; 666 ± 8d; 583 ± 6kg) heifer blocks given HC and HF twice daily to four cannulated heifers per block for four, 28d periods with four days of total fecal and urine collection. Ammonia volatilization was analyzed once per period per heifer from a 200 g combination of urine and feces. The rations (25% HC vs. 75% HF forage; corn silage, alfalfa, and grass hay) were fed restrictedly to provide 0.22 Mcal ME and 1.9 g N per kg $EBW^{0.75}$. Organic matter intake was lower for heifers fed HC ($P<0.01$), however due to improved OM digestibility (75.97 HC vs. 71.53 HF ± 0.70%; $P<0.01$), intake of digestible OM was not different between treatments ($P>0.20$). NDF digestibility was not significantly affected by dietary treatment (52.92 HC vs. 51.18 HF ± 1.46%; $P>0.20$). Nitrogen intake was greater for the heifers fed HC (162 HC vs. 155 HF ± 2g/d; $P<0.01$), however fecal N excretion tended to be greater for HF ($P<0.06$) because of improved apparent N digestibility for HC ($P<0.01$). Urinary N excretion was not affected by treatment ration ($P>0.20$), leading to greater overall N retention for heifers fed HC ($P<0.01$). The ammonia volatilization rate, when adjusted to reflect the greater production of urine and feces by HF, was greater for heifers fed HF (28.74 HC vs. 33.15 HF ± 1.00g/d; $P<0.01$). Nitrogen retention was not different between Y and O heifers (34 Y vs. 38 O ± 2 g/d; $P>0.20$). The proportion of absorbed N that was retained was therefore greatest in Y heifers and those fed HC ($P<0.01$), however there were no significant interactions between age and ration. From these results we conclude that Y and O heifers fed HC will have improved efficiency of OM and N utilization when intake is controlled.

Key Words: Dairy heifers, Forage:concentrate, Digestibility

599 The effect of limit-feeding gravid Holstein heifers on first lactation milk production. P. Hoffman*, C. Simson, and M. Wattiaux, *University of Wisconsin*, *Madison*.

A study was conducted to evaluate the effect of limit-feeding gravid Holstein heifers on growth, feed efficiency, fecal excretion, behavior and first lactation milk production. Gravid Holstein heifers (n=54) weighing 464 kg were randomly assigned to one of nine pens containing six heifers/pen. Heifers were fed one of three experimental diets for 111 d. Control (C100) heifers were ad libitum fed a diet containing 11.3 percent CP and 2.46 Mcals/kg of metabolizable energy (ME). Two experimental diets of increased nutrient density were formulated to contain 12.7 and 14.2 percent CP and 2.55 and 2.68 Mcals/kg of ME respectively. Feed intake of these diets was limited to 90 (L90) and 80 (L80) percent of C100 intake. Nutrient intake, growth, fecal excretion, blood profiles, behavior and lactation performance of heifers were evaluated. Limit-fed heifers (L90, L80) consumed less ($P<0.01$) DM (9.02, 8.30 vs 9,66 kg/d), but limit-feeding had no effect ($P>0.10$) on any measure heifer growth. Feed efficiency was improved ($P<0.09$) by 1.04 kg DM intake/kg gain by limit-feeding. Heifers fed L90 and L80 excreted 0.36 and 0.86 kg less ($P<0.10$) DM but excreted similar amounts of N and P as compared to heifers fed C100. Limit-fed heifers spent less ($P<0.05$) time eating, more ($P<0.01$) time standing without eating and vocalized more ($P<0.03$) than heifers fed C100. Milk production and parturition data from control and limit-fed heifers were collected between 0-150 DIM. Dystocia indexes, calf BW and postpartum BW of limit-fed heifers were not different ($P>0.44$) between limit-fed heifers and heifers fed C100. Daily milk yield was similar ($P>0.66$) at 30.6, 30.7 and 32.2 kg/d for heifers fed C100, L90 and L80 respectively. Likewise, milk fat and protein composition was not different ($P>0.36$) between limit-fed and C100 fed heifers. Projected 305 first lactation milk yields were 8303, 8633, and 8948 kg/305 d for C100, L90 and L80, respectively. Data suggest limit feeding gravid Holstein heifers improved feed efficiency, decreased fecal excretion and had little effect on first lactation performance.

Key Words: Heifers, Limit feeding, Milk production

Ruminant Nutrition: Minerals & Vitamins

600 Effect of dietary vitamin A restriction on marbling in growing cattle. M. Gorocica-Buenfil*, F. Fluharty, C. Reynolds, and S. Loerch, *The Ohio State University*, *Wooster*.

To determine the effect of the duration of dietary vitamin A restriction on the site of fat deposition in growing cattle, 60 Holstein steers (BW = 219.1 kg) were fed a high-moisture corn-based diet with 2,200 IU supplemental vitamin A/kg DM (C) or no supplemental vitamin A for a long (243 d; LR) or short (131 d; SR) restriction before harvest at 243 d. The SR steers were fed the C diet for the first 112 d. Steers were penned individually and feed was offered ad libitum. Jugular vein blood samples for serum retinol analysis were taken on d 1, 112 and 243. Feedlot performance (ADG, DMI and G:F) was not affected ($P > 0.05$) by vitamin A restriction. At the end of the experiment, the intramuscular fat content of the longissimus muscle was 33% greater ($P < 0.05$) for LR vs. C steers (5.6 vs. 4.2% Ether extractable fat (EE), respectively), while EE of the longissimus muscle of SR steers was 3.9%. Depth of BF and KPH percentage were not affected ($P = 0.44$ and 0.80, respectively) by vitamin A restriction. Marbling scores were numerically greater for the LR steers (LR = 433.8, SR = 370.6, C = 401.7; $P = 0.36$). Carcass weight, composition of edible carcass and YG were similar among treatments ($P > 0.10$). Liver (LR = 6.1, SR = 6.5, and C = 44.7 μg/g; $P < 0.01$) but not subcutaneous fat retinol (LR = 0.5, SR = 0.7, and C = 0.6 μg/g; $P = 0.33$) was reduced in LR and SR steers. Vitamin A restriction reduced ($P < 0.01$) serum retinol by d 112 (LR = 2.8, SR = 4.2, and C = 3.8 μg/dL). On d 243, LR and SR steers had similar serum retinol levels and these were lower ($P < 0.01$) than those of C steers (LR = 2.1, SR = 2.5, and C = 3.7 μg/g). These results suggest that serum and liver retinol levels can be reduced

feeding a low vitamin A diet for 112 d. Restricting vitamin A intake for 243 d increased intramuscular fat percentage without affecting subcutaneous or visceral fat deposition, feedlot performance, or carcass weight. Restricting vitamin A intake for 131 d or less appears to be insufficient to affect the site of fat deposition in Holstein steers.

Key Words: Vitamin A, Steers, Marbling

601 Bioavailability of copper from copper glycinate when fed in the presence of high sulfur and molybdenum. S. L. Hansen*[1], P. Schlegel[2], K. E. Lloyd[1], L. R. Legleiter[1], and J. W. Spears[1], [1]*North Carolina State University*, *Raleigh*, [2]*Pancosma, S.A.*, *Geneva, Switzerland*.

Sixty Angus (n=29) and Angus-Simmental cross (n=31) steers, averaging 9 mo of age and 277 kg initial BW, were used in a 148-d study to determine the bioavailability of copper glycinate (CuGly) relative to feed grade copper sulfate ($CuSO_4$) when supplemented to diets high in sulfur (S) and molybdenum (Mo). Steers were blocked by weight within breed and assigned to one of five treatments: 1) control (no supplemental Cu), 2) 5 mg Cu/kg DM from $CuSO_4$, 3) 10 mg Cu/kg DM from $CuSO_4$, 4) 5 mg Cu/kg DM from CuGly, and 5) 10 mg Cu/kg DM from CuGly. Steers were individually fed a corn-silage based diet (analyzed 7.9 mg Cu/kg DM), and supplemented with 2 mg Mo/kg of diet DM and 0.15% S for 120 d (Phase 1). Steers were then supplemented with 6 mg Mo/kg of diet DM and 0.15% S for 28 d (Phase 2). Average daily gain and G:F were improved by Cu supplementation regardless of source (P = 0.01). Final ceruloplasmin (Cpl), plasma Cu and liver Cu values were greater (P < 0.05) in steers fed supplemental Cu compared with controls. Plasma Cu, liver Cu and Cpl values were higher (P < 0.05) in steers supplemented with 10 mg Cu/kg DM verses those supplemented with 5 mg Cu/kg DM. Based on multiple linear regression of final plasma Cu, liver Cu and Cpl values on dietary Cu intake in Phase 1 (2 mg Mo/kg DM), bioavailability of Cu from CuGly relative to $CuSO_4$ was 140 (P = 0.10), 131 (P = 0.12) and 140% (P = 0.09), respectively. Relative bioavailability of Cu from CuGly was greater (P = 0.01; 144, 150 and 156%, based on plasma Cu, liver Cu and Cpl, respectively) than from $CuSO_4$ following supplementation of 6 mg Mo/kg DM for 28 d. Results of this study suggest that Cu from CuGly is more available than $CuSO_4$ when supplemented to diets high in S and Mo.

Key Words: Bioavailability, Cattle, Copper

602 Plasma diamine oxidase as a biomarker of copper deficiency in the bovine. L. R. Legleiter* and J. W. Spears, *North Carolina State University*, *Raleigh*.

Twenty-eight Angus steers (n = 11) and heifers (n = 17) were used to determine the efficacy of plasma diamine oxidase activity as a biomarker of copper (Cu) deficiency in the bovine. The steers and heifers were born to dams assigned to one of the following treatments: 1) control (10 mg Cu and 20 mg Mn/kg DM), 2) Cu deficient (-Cu; 2 mg molybdenum (Mo) and 20 mg Mn/kg DM), and 3) Cu deficient plus high Mn (-Cu+Mn; 2 mg Mo and 500 mg Mn/kg DM). Molybdenum was used to induce Cu deficiency. Following weaning at 7 mo of age calves were maintained on the above treatments through 15 mo of age and were individually fed via Calan gates. Plasma diamine oxidase (DAO), a Cu-dependent enzyme responsible for the degradation of cadaverine and putrescine, was measured on d 420. Using Mo to induce Cu deficiency was successful as indicated by indices of Cu status (Table 1). Plasma Cu was significantly decreased (P < 0.01) in cattle receiving -Cu and -Cu+Mn treatments. High dietary Mn (-Cu+Mn) further depressed (P < 0.01) plasma Cu compared to the -Cu diet alone. Liver Cu stores and ceruloplasmin activity were significantly reduced (P < 0.01) in Cu deficient cattle compared to the controls. Plasma diamine oxidase activity was decreased (P < 0.01) in Cu deficient animals compared to controls and tended (P = 0.19) to be further depressed in animals receiving high Mn. These data demonstrate that plasma diamine oxidase activity can be used as a biomarker of Cu deficiency in the bovine.

Table 1. Copper indices of cattle fed control, Cu deficient, and Cu deficient plus high Mn diets.

	Control	-Cu	-Cu+Mn	SEM
Plasma Cu, mg/L[a,b]	1.32	0.37	0.10	0.04
Liver Cu, mg/kg DM[a]	178.1	4.6	2.3	8.0
Ceruloplasmin, mg/dL[a]	33.6	6.6	3.6	2.6
Diamine oxidase, U/L[a,c]	167.0	61.3	31.1	15.9

[a]Control vs. -Cu & -Cu+Mn (P < 0.01); [b]-Cu vs. -Cu+Mn (P < 0.01); [c]-Cu vs. -Cu+Mn (P = 0.19)

Key Words: Cattle, Copper, Diamine oxidase

603 Effect of dietary potassium level and source on performance of finishing cattle fed varying dietary sulfur. R. S. Fry*, K. E. Lloyd, and J. W. Spears, *North Carolina State University*, *Raleigh*.

An experiment was conducted to determine the effects of potassium (K) level and source on performance of finishing cattle fed diets low or high in sulfur (S). Sixty Angus and Angus-cross heifers (average initial BW 368 kg) were blocked by previous treatment and weight and randomly assigned to treatments. Treatments consisted of: 1) control (no supplemental S or K), 2) 0.30% supplemental K from KCl, 3) 0.30% supplemental K from K_2CO_3 (DCAD Plus™), 4) 0.30% supplemental S from NH_4SO_4, 5) 0.30% supplemental S from NH_4SO_4 and 0.30% K from KCl and 6) 0.30% supplemental S from NH_4SO_4 and 0.30% K from K_2CO_3. The control diet analyzed 0.51% K and contained approximately 0.15% S. Heifers were housed in pens of 12 and individually fed using electronic Calan gates. Cattle were slaughtered after receiving a high corn finishing diet for either 101 or 121 d. Equal numbers of heifers per treatments were harvested on each day. Potassium addition to the control diet did not affect performance or carcass characteristics regardless of dietary S. Longissimus muscle area tended (P < 0.10) to be affected by a K source × S interaction. Heifers not receiving supplemental S had larger longissimus muscle areas (P < 0.01; 83.9 vs. 75.3 cm^2) when fed K_2CO_3 compared with those supplemented with KCl. Potassium source did not affect longissimus muscle area of heifers fed high dietary S. Addition of 0.30% S to the diets reduced (P < 0.01) ADG (1.49 vs. 1.20 kg), and ADFI (8.73 vs. 7.19 kg) but did not affect G:F (0.172 vs. 0.167). Hot carcass weights (P < 0.01; 313.7 vs. 289.2 kg) and dressing percentage (P = 0.06; 59.1 vs. 58.1) were also lower in S supplemented than in non S-supplemented heifers. Results of this study indicate that increasing dietary K will not alleviate reduced ADG and ADFI observed in finishing cattle fed diets high in S.

Key Words: Cattle, Potassium, Sulfur

604 Effect of increasing dietary concentrations of dried distillers grains plus solubles on P balance in finishing steers. C. Benson, C. Wright*, J. McCarthick, and R. Pritchard, *South Dakota State University*, *Brookings*.

Eight crossbred steers (initial BW = 442 ± 15.2 kg) were used in a replicated Latin Square design to determine the effect of increasing dietary concentrations of dried distillers grains plus solubles (DDGS) on P balance. One steer had to be removed from the study due to health concerns. All data collected on this animal were removed and statistical analyses were performed as an unbalanced replicated Latin square with animal as the experimental unit. Regression analysis was also performed, regressing fecal P, urine P, total P excretion, and P retention on P intake. The control diet contained 79% dry rolled corn (DRC), 10% cottonseed hulls, 6% soybean meal (SBM), and 5% mineral supplement (total diet P concentration = 0.26%). In each of the remaining three diets, all of the SBM and a portion of the DRC were removed and replaced with DDGS at 12%, 24%, and 36% of the diet (total diet P concentrations = 0.28%, 0.33%, and 0.37%, respectively). Steers were housed in indoor, slatted-floor pens (1.7 x 2.6 m) during a 21-d diet acclimation period prior to a 5-d total fecal and urine collection period. All samples (feed ingredients, feed refusals, feces, and urine) were analyzed for P concentration. Phosphorus intake increased from 18.6 to 27.8 g/d (linear; $P = 0.007$) as the concentration of DDGS was increased in the diet. Fecal P was not affected by treatment. Urinary P (g/d; linear; $P = 0.001$), total P excretion (g/d; linear; $P = 0.025$), and P retention (g/d; linear; $P = 0.020$) increased as the level of DDGS in the diets increased. In regression analyses, fecal P (g/d; $P_{fecal}=0.003+0.416P_{intake}$; $P = 0.003$; $r^2 = 0.29$), total P excretion (g/d; $P_{total}=5.324+0.605P_{intake}$; $P = 0.001$; $r^2 = 0.47$), and P retention (g/d; $P_{retained}=-12.306+0.641P_{intake}$; $P = 0.001$; $r^2 = 0.50$) were influenced by P intake. Urinary P (g/d) tended to be influenced ($P_{urinary}=0.537+0.189P_{intake}$; $P = 0.11$; $r^2 = 0.10$) by P intake. Results of the experiment demonstrate that as the levels of DDGS in the diets of finishing steers increases, P excretion increases.

Key Words: Distillers grains, Phosphorus, Steers

605 Phosphorus digestion in lactating cows fed diets containing beet pulp. T. H. Yang*[1], K. F. Knowlton[1], C. Shang[1], J. A. Voelker Linton[2], and M. S. Allen[2], [1]*Virginia Polytechnic Institute and State University*, *Blacksburg*, [2]*Michigan State University*, *East Lansing*.

The objective of the study was to evaluate the effect of increasing dietary beet pulp (BP) content on duodenal and fecal flow of total phosphorus (P) and phytic-acid (PA) P. Eight multiparous Holstein cows fitted with ruminal and duodenal cannulae were fed diets containing 40% forage (corn silage and alfalfa silage) and 0, 6.1, 12.1 or 24.3% unmolassed, pelleted BP (replacing high moisture corn grain on a DM basis) in a replicated 4x4 Latin square design with 21-d periods. The nutrient content of BP averaged 39.9% NDF, 8.9% CP, 8.0% indigestible NDF, 3.9% starch, and 0.29% free glucose on a DM basis. Duodenal digesta and feces were collected every 9 h on d 12-14, and rumens were evacuated and subsampled 4 h after feeding on d 20 and 2 h before feeding on d 21. Samples were composited by cow within period and analyzed for P (nitric/perchloric digestion) and PA-P (anion-exchange method). Linear and quadratic effects of increasing BP content were analyzed using Proc Mixed of SAS. Dietary P and PA content were reduced linearly with increasing percent BP (0.59, 0.58, 0.57, 0.56 %P and 0.15, 0.14, 0.13, 0.11 %PA, respectively). With increasing BP content, P intake, ruminal P content, and rumen P pool size decreased. Digestion, duodenal flow and fecal excretion of P were not affected. With increasing dietary BP content, PA intake was reduced, ruminal pool size was reduced, and rumen turnover time (h) was increased. Apparent ruminal digestibility of PA was decreased linearly with increasing BP (36.5, 31.8, 24.6, 13.6 %; $P < 0.02$), and apparent total tract PA digestibility was similarly affected (85.3, 82.7, 82.1, 79.1%; $P < 0.01$). As previously reported, increasing BP was associated with reduced ruminal starch digestion and increased post-ruminal starch digestion. Fecal excretion of PA-P averaged 5.2 g/d. Replacing starchy grains with BP reduced digestion of PA-P, and the majority of the disappearance of PA-P occurred post-ruminally.

Key Words: Phytic acid digestion, Dairy cattle

606 Modeling phosphorus utilization in dairy cows in Ontario. E. Kebreab*, J. France, N. E. Odongo, and B. W. McBride, *University of Guelph*, *Guelph, Ontario, Canada*.

Phosphorus (P) is a key mineral essential to nearly every aspect of metabolism in a dairy cow and needs to be supplied in sufficient quantity. However, dairy cows use less than 40% of dietary P; the rest is excreted mainly in feces, which can lead to environmental pollution. The objective of this study was to develop empirical models of P utilization and evaluate an extant mechanistic model. Data were collected from 12 lactating Holstein cows (678±17 kg body weight, 30 to 52 DIM) fed various amounts of P ranging from 63 to 101 g/d. Dry matter intake (DMI), P intake (total, tP, and digestible, dP), P excreted in feces and urine, P secreted in milk, and plasma P were recorded. An empirical model was developed using the REG procedure in SAS. Digestible P intake was highly related to fecal P, explaining 73.4% of the variation. Adding tP to the regression increased the r^2 to 99.6% (Fecal P, g/d = 34.2 + 0.59 tP – 0.85 dP). Urinary P excretion correlated best with plasma P but the relationship was not significant, probably because within the range of P fed, threshold plasma P (3 mmol/L) was not reached. Milk P secretion best related to DMI (r^2=0.34), with addition of tP to the model increasing the r^2 to 45.2% (Milk P, g/d = 0.00046 DMI + 0.08 tP). The data were also inputted to an extant mechanistic P model to generate predictions of fecal P values and the results evaluated using mean square prediction error (MSPE). The difference between overall observed (50.1 g/d) and predicted mean (54.2 g/d) fecal P output was 4.1 g/d. Root MSPE was 8.2 g/d, which was 16% of observed mean. Although most of the calculated error (75%) was due to random variation, 24% was due to central deviation from the mean due to overestimation of fecal P. This bias is most probably because the model was developed on cows fed grass silage-based diets while in the current experiment, the cows were fed corn silage/alfalfa haylage-based diets. Both analyses show that dietary manipulation of dP can reduce P excretion but under current conditions, urinary P excretion does not pose environmental problems. However, there is a need to calibrate the extant model to make it more relevant to cows in North America.

Key Words: Phosphorus, Modeling, Pollution

607 Calcium and phosphorus supplementation for transition cows. V. Moreira* and C. Coxe, *Louisiana State University*, *Franklinton*.

The objective of this study is to evaluate the performance of cows fed Ca and P either 15% below or 20% above NRC (2001) estimated absorbable requirement for 30 days post-partum. Nine of the 12 planned blocks (four cows per block) have completed the study. Multiparous cows were housed in a free-stall barn fit with electronic gates at least 20 days before expected calving date. Cows were blocked

according to calving date. Dry cows were fed a common TMR designed to contain Ca concentration (0.32% DM) slightly below NRC (2001) recommendation until two days after calving to minimize the risk of clinical hypocalcaemia. Dietary P was set slightly above recommendation (0.33% DM). Treatments were randomly distributed according to a 2x2 factorial arrangement (**HCa:HP** = 0.72%:0.48%; **HCa:LP** = 0.72%:0.36%; **LCa:HP** = 0.54%:0.48%; **LCa:LP** = 0.54%:0.36%; percents total mineral content in diet DM). Intake (**DMI**) and milk yield were recorded daily. Digestibilities (**DMD**) were determined during three days of total fecal collection for each block of cows averaging 20 DIM. Milk composition was determined when cows averaged 30 DIM. Data were analyzed as Randomized Block design with repeated measures using mixed procedures (SAS, version 9.1). Three cows were removed from the study because of unrelated problems. Milk production in the previous lactation and average DMI of the second week pre-partum were used as covariates for milk yield and DMI post-partum, respectively. Milk yield and DMI were similar for all treatments ($P \geq 0.10$). Cows averaged 44.3 kg/d of milk (SEM = 1.2 kg/d) and DMI was 21.6 kg/d (SEM = 0.75 kg/d) between 5 and 30 DIM. Cows fed diets containing higher Ca had lower ($P \leq 0.05$) DMD and tended to have higher peak of milk ($P \leq 0.08$). Milk contained 3.36% (SEM = 0.16%) fat and somatic cell scores averaged 2.90 (SEM = 0.51). Milk protein content was lower ($P = 0.001$) for cows fed HCa. Changes in body weight and body condition scores were not significantly affected by treatment. The partial results suggest cows fed P 15% below NRC estimated absorbable requirement supported high milk production in early lactation.

Key Words: Calcium, Phosphorus, Early lactation dairy cows

608 Development of methodologies to reduce the DCAD of hays for transition dairy cows. R. L. Horst*[1], K. T. Pecinovsky[2], K. J. Moore[2], D. R. Thoreson[2], J. R. Russell[2], E. C. Brummer[2], and J. P. Goff[1], [1]*National Animal Disease Center*, *Ames, IA*, [2]*Iowa State University*, *Ames*.

Excessive potassium (K) content of forages can cause metabolic alkalosis in the cow and subsequently hypocalcemia and milk fever. Reducing K content of forages can be a means of reducing the incidence of milk fever and acheiving a more favorable dietary cation anion difference (DCAD) for the transition cow. A reduction in forage K can be achieved by restricting K fertilization. In addition, increasing the chloride (Cl) content could also result in a more favorable DCAD for the periparturient cow. This study tests the hypothesis that Cl fertilization without K addition to hays will result in decreasing forage DCAD. Four forage species were seeded in four blocks of four 3 x 16 m plots. In the spring of 2004 each plot was divided into four subplots that were randomly treated with one of four treatments including 1) Control (C); 2) 100 lbs Cl as $CaCl_2$; 3) 200 lbs K_2O as K_2CO_3; and 4) Cl + K_2O as a combination of treatments 2 and 3. The four forage species to be evaluated were:Smooth Bromegrass (SB); Orchardgrass (OG); Reed Canarygrass (RC); and 4) Alfalfa (AF). In plots not receiving K_2O fertilization the K content of the plants was lower ($p<.01$) regardless of species and across all cuttings (Control, 1.92%; $CaCl_2$, 1.77%) relative to those receiving K_2O (K_2O, 2.15% and Cl+K_2O, 2.24%). Plots fertilized with Cl resulted in a 2-3 fold elevation in tissue Cl in all the hays tested ($p<.01$). This effect was observed for each of the three cuttings. Mean treatment Cl values across all cutting and species were control, 0.32%; $CaCl_2$, 0.90%; K_2O, 0.34%; Cl+K_2O, 0.84%. DCAD was also significantly ($p<0.05$) reduced in plots treated with Cl alone relative to C; OG (365 vrs 600); RC (105 vrs 438); and OG (172 vrs 426). The combination of Cl + K_2O resulted in an attenuation of this effect. Alfalfa DCAD appeared to be unaffected by Cl fertilization due to a compensatory Na accumulation. These data suggest that Cl fertilization without K addition may be an effective means of decreasing the DCAD content of hay. The effect of Cl fertilization on yield, hay quality and palatability is currently under investigation.

Key Words: Chloride fertilization, Forage, Milk fever

609 Effect of trace mineral source on lactation and reproductive performance of dairy cattle. F. Toni[1], L. Grigoletto[1], C. J. Rapp*[2], M. T. Socha[3], and D. J. Tomlinson[3], [1]*Kriton Biological Services*, *Correggio, Italy*, [2]*Zinpro Animal Nutrition*, *Boxmeer, Netherlands*, [3]*Zinpro Corporation*, *Eden Prairie, MN*.

One hundred eighty multiparous Holstein cows (90 cows/treatment) were blocked according to calving date and randomly assigned to a study to determine the effect of trace mineral source on performance. Treatments were 1) all trace minerals supplied by inorganic sources or 2) 360 mg of zinc, 200 mg of manganese and 125 mg of copper per day of inorganic minerals replaced with Availa®4 (Zinpro Corporation). Neither level nor source of cobalt supplementation differed between dietary treatments. Cobalt was supplemented as cobalt carbonate to supply 23 mg cobalt per day. Cows received their respective treatments from 60 d prior to calving through 200 days of lactation. Lactation diets were formulated to provide 79 mg/kg zinc, 57 mg/kg manganese, 15 mg/kg copper and 1 mg/kg cobalt (supplemental levels, DM basis). Cows were milked 2X/d and milk yield was recorded at each milking. Treatments were included in a supplement that was fed to individual animals via automatic feeders. Animal (cow) was the experimental unit. Lactation data and body condition scores were analyzed as repeated measures. Replacing inorganic trace minerals with Availa®4 tended to increase (P=0.06) protein yield (1.09 vs. 1.05 kg/d) while decreasing (P=0.15 somatic cell counts (linear score: 2.89 vs. 3.19). There was no effect of treatment on milk yield or milk composition. Feeding Availa®4 increased (P<0.01) body condition score (2.97 vs. 2.86), and decreased (P=0.02) culling rate (13.3 vs. 25.6%). Feeding Availa®4 tended (P=0.07) to increase incidence of retained placentas (13.3 vs. 6.7%), while tending to decrease (P=0.15) incidence of metritis (14.4 vs. 16.7%) and increase (P=0.15) first service conception rate (21.9 vs. 19.1%). In conclusion, replacing inorganic trace minerals with Availa®4 tended to improve lactation and reproductive performance and decreased culling in dairy cattle.

Key Words: Trace minerals, Lactating dairy cow, Reproduction

610 Sodium zeolite A supplementation to lactating Holsteins. K. Turner*[1], B. Nielsen[2], and C. O'Connor[2], [1]*The University of Georgia*, *Athens*, [2]*Michigan State University*, *East Lansing*.

Sodium zeolite A (SZA) has been shown to alter calcium and phosphorus metabolism in ruminants; however, clarification of the mechanisms by which this occurs is needed and alterations in milk mineral concentrations have not been fully investigated. Additionally, SZA has been suggested to alter bone metabolism in horses, as well as reduce skeletal injury rates. Therefore, twenty Holstein dairy cows in either their first or second parity were used to determine the effects of sodium zeolite A (SZA) on plasma and milk mineral concentrations as well as markers of bone metabolism. The cows were pair-matched by parity and milk production and placed into one of two groups – SZA supplemented (SS) or control (CO). Individual cow milk production and feed intake were recorded daily. All cows received their normal

total mixed ration, but SS cows also were supplemented with SZA at a dosage level of 2% of the diet. Milk, blood, and feed samples were taken on d 0, 15, and 30 for mineral analysis. Blood was also used for osteocalcin (OC) and deoxypyridinoline (DPD) determination. Treated cows decreased feed intake and milk production from d 15 to d 30 (P<0.007) and had lower feed intakes and milk production than CO cows on both d 15 and d 30 (P<0.003). On d 15, SS cows had higher plasma silicon concentrations than CO cows (P=0.01) but there was no difference on d 30 (P=0.71). Overall, plasma aluminum concentration was increased by SZA (P=0.002). SS-cows had higher milk aluminum concentrations than CO cows (P=0.02). Milk phosphorus concentration decreased from d 15 to d 30 in SS cows (P=0.007). On d 15 and 30, milk phosphorus concentrations were lower in SS cows than CO cows (P<0.03). Treated cows had higher plasma calcium concentrations, and lower plasma phosphorus concentrations than CO cows (P<0.0002). There was no treatment*day effect on osteocalcin, DPD, or OC to DPD ratio (P>0.24), suggesting bone metabolism was not affected. Sodium zeolite A decreased feed intake, milk production, and plasma phosphorus concentration, possibly via a phosphorus deficiency created by the aluminum intake. If SZA is added to the diet of a ruminant, additional phosphorus may be needed to prevent this induced deficiency.

611 The relationship between dry matter intake and acid-base status of lactating dairy cows as manipulated by dietary cation-anion difference. W. Hu*[1], L. Kung, Jr.[1], and M. R. Murphy[2], [1]*University of Delaware*, *Newark*, [2]*University of Illinois*, *Urbana*.

Our objective was to examine, using mixed model statistical analysis, the potential relationship between dry matter intake (DMI) and acid-base status of lactating dairy cows as manipulated by dietary cation-anion difference [DCAD; defined as milliequivalents of Na + K - Cl per 100 grams of feed dry matter (DM)]. A database was developed from 16 studies of DCAD effects on DMI and productivity of lactating dairy cows in which 21 experiments, including 88 dietary treatments (DCAD ranging from -19.1 to 72.7) and 337 cows, occurred. Observed DMI values were adjusted for the study effects. Adjusted DMI increased quadratically with increasing DCAD ($P < 0.001$; $R^2 = 0.76$), peaking at 47 meq/100 g of DM. The adjusted DMI also increased as blood HCO_3^- concentrations (quadratic, $P < 0.001$; $R^2 = 0.83$), blood pH (linear, $P < 0.001$; $R^2 = 0.82$), and urinary pH (quadratic, $P = 0.009$; $R^2 = 0.66$) increased. The relationships between adjusted DMI and blood HCO_3^-, blood pH, and urinary pH suggested that DMI was closely associated with acid-base status of dairy cows. It appears that DCAD affects systemic acid-base physiology which, in turn, affects feed intake of dairy cows.

Key Words: Dry matter intake, Acid-base status, Dairy cows

612 Influence of altering dietary cation anion difference on milk yield and its composition by early lactating *Nili Ravi* buffaloes in summer. M. A. Shahzad*, M. Sarwar, M. Nisa, and A. Khan, *University of Agriculture*, *Faisalabad, Pakistan.*

Influence of -110, +110, +220 and +330 mEq/kg dry matter (DM) of dietary cation anion difference (DCAD) on milk yield and its composition by early lactating *Nili Ravi* buffaloes was examined in a randomized complete block design and data were analyzed by using analysis of variance technique while means were compared by using Duncan's Multiple Range test. Four DCAD levels were randomly allotted to four groups, three buffaloes in each group. A linear increase in nutrients (dry matter, crude protein, neutral detergent fiber, acid detergent fiber) and water intakes were recorded with increasing the DCAD level. Buffaloes fed +220 and +330 mEq/kg DM, DCAD diets showed better energy and nitrogen balance than those fed -110 and +110 mEq/kg DM, DCAD diets. A significant increase in blood pH and HCO3 was noticed with increasing DCAD level. Serum (Na + K) – (Cl + S) increased linearly with increasing the DCAD level, while serum chloride was higher in buffaloes fed -110 DCAD diet. Serum calcium increased significantly with decreasing the DCAD level while serum magnesium and phosphorus remained unaffected. Urine pH was increased significantly with increasing DCAD level. A linear increase in milk yield was also noticed with increasing the DCAD level. Milk fat% increased significantly with increasing the DCAD while all other milk constituents remained unaltered. In conclusion, high DCAD (+220 and +330) diets not only increased the dry matter and water intake but also improved milk yield and milk fat% in early lactating buffaloes during summer.

Key Words: Early lactating buffaloes, Dietary cation anion difference (DCAD), Nitrogen and energy balance

613 Influence of altering dietary cation anion difference on growth performance of growing buffalo calves. M. Sarwar*, M. A. Shahzad, and M. Nisa, *University of Agriculture*, *Faisalabad, Pakistan.*

Influence of -110, +110, +220 and +330 mEq/kg of dry matter (DM) dietary cation anion difference (DCAD) on growth performance of growing buffalo male calves was examined in a randomized complete block design. The DCAD was calculated by using equation (Na + K – Cl +S) mEq/kg DM. Four DCAD diets were randomly allotted to four groups, five calves in each group. A linear increase (P<0.05) in nutrients (dry matter, crude protein, neutral detergent fiber, acid detergent fiber) intake was recorded with increasing the DCAD level. The digestibilities of nutrients were higher (P<0.05) in calves fed -110 DCAD diet than those fed +110, +220 and +330 DCAD diets. Calves fed +330 DCAD diet had higher nitrogen balance than those fed -110 and +110 DCAD diets. Blood pH and serum HCO_3 increased (P<0.05) with increasing the DCAD level. Serum (Na + K) – (Cl + S) increased linearly (P<0.05) with increasing the DCAD level while serum chloride was higher (P<0.05) in calves fed -110 DCAD diet. Serum calcium increased (P<0.05) with decreasing the DCAD level while serum magnesium and phosphorus remained unaffected. Calves fed -110 DCAD diet had higher (P<0.05) Ca balance than those fed +110, +220 and +330 DCAD diets. Urine pH increased (P<0.05) with increasing the DCAD level. Calves fed +220 and +330 DCAD diets gained more weight (P<0.05) than those fed -110 and +110 DCAD diets. In conclusion, increased DCAD level not only increased the dry matter intake but also improved the weight gain in growing buffalo male calves.

Key Words: Buffalo calves, DCAD, Nitrogen and calcium balance