RUMINANT NUTRITION IX

0683 Effects of supplemental zinc, copper, and manganese concentration and source on performance and carcass characteristics of feedlot steers. E. Caldera*[1], J. J. Wagner[1], K. Sellins[1], T. E. Engle[1], S. B. Laudert[2], and J. Spears[3], [1]*Colorado State University, Fort Collins,* [2]*Micronutrients, Indianapolis, IN,* [3]*North Carolina State University, Raliegh.*

Four-hundred cross-bred steers (initial BW 335 ± 9.6 kg) were utilized to investigate the effects of supplemental Zn, Cu, and Mn concentration and source on performance and carcass characteristics of feedlot steers fed a high concentrate steam flaked corn-based finishing diet for 159 d and zilpaterol hydrochloride for the last 21 d before slaughter (5-d withdrawal). The experimental design was a randomized complete block design. Steers were blocked by weight and randomly assigned within block to one of the five treatments (eight pens/treatment; 10 hd/pen). Treatments consisted of: 1) 90 mg of Zn/kg DM from $ZnSO_4$; 17.5 mg of Cu/kg DM from $CuSO_4$; 48 mg of Mn/kg DM from $MnSO_4$; 2) 30 mg of Zn/kg DM from Zn hydroxychloride; 10 mg of Cu/kg DM from basic Cu chloride; 20 mg of Mn/kg DM from Mn hydroxychloride; 3) 45 mg of Zn/kg DM from hydroxychloride; 12.5 mg of Cu/kg DM basic Cu chloride; 29.5 mg of Mn/kg DM from Mn hydroxychloride; 4) 60 mg of Zn/kg DM from Zn hydroxychloride; 15 mg of Cu/kg DM from basic Cu chloride; 39 mg of Mn/kg DM from Mn hydroxychloride; and 5) 90 mg of Zn/kg DM from Zn hydroxychloride; 17.5 mg of Cu/kg DM from basic Cu chloride; 48 mg of Mn/kg DM from Mn hydroxychloride. Steers were individually weighed on d -1, 0, 55, 112, and pen-weighed two consecutive days at the termination of the experiment. Steers were transported to a commercial abattoir, slaughtered, and individual carcass data and liver samples were collected. Initial pen BW was used as a covariate in the statistical analysis and significance was determined at $P \leq 0.05$. No differences were observed for final body weight ($P > 0.42$). Overall ADG, DMI, and feed efficiency were similar across treatments. Hot carcass weight, dressing percentage, yield grade, LMA, adjusted fat thickness, KPH, and marbling score were similar across treatments. Concentrations of Zn, Cu, and Mn in livers and blood samples collected on d 112 and at harvest were similar across treatments. These data indicate that under the conditions of this experiment, supplemental Zn, Cu, and Mn concentration and source had no impact on performance and carcass characteristics in feedlot steers.

Key Words: cattle, feedlot, trace mineral

0684 Decreasing dietary calcium to potentiate changes in beef tenderness with zilpaterol hydrochloride supplementation. C. L. Van Bibber-Krueger*, K. A. Miller, and J. S. Drouillard, *Kansas State University, Manhattan.*

Dietary calcium concentrations were manipulated during supplementation of zilpaterol hydrochloride (ZH) to evaluate impact on feedlot performance, carcass characteristics, and beef tenderness using 96 heifers (BW 392 kg ± 3.2). We hypothesized that temporary depletion followed by repletion of dietary calcium before harvest would increase intracellular calcium concentrations, thus stimulating postmortem activity of calcium-dependent proteases. Heifers were stratified by initial BW and randomly assigned, within strata (block), to treatments consisting of a finishing diet in which calcium was added in the form of limestone (+Ca) and a diet in which the limestone had been removed (-Ca) during ZH supplementation. Cattle were fed a common diet before ZH supplementation, and 24 d before slaughter ZH was added to the diet with and without the supplemental calcium. Calcium content of the diets during ZH supplementation was 0.74% or 0.19% (diet DM) for +Ca and-Ca, respectively. Zilpaterol hydrochloride was fed for 21 d, then removed from the diet 3 d before harvest. The final 3 d before harvest, limestone was added back into the-CA diet at 0.74% of diet DM. Heifers were housed in concrete surfaced pens with eight animals per pen (six pens per treatment). At the end of the finishing phase, animals were weighed and shipped to an abattoir in Holcomb, KS. Severity of liver abscesses and HCW were collected the day of harvest, and after a 48-h chill USDA yield and quality grades, KPH, LM area, 12th rib fat thickness were determined and boneless loin section was collected for Warner-Bratzler shear force determination. Removal of calcium did not affect Warner-Bratzler shear force values ($P = 0.64$). In addition, ADG, DMI, final BW and feed efficiency were unaffected by treatment ($P > 0.05$). Carcass measurements also were unaffected by the decrease in dietary calcium ($P > 0.05$). In conclusion, temporary depletion of dietary calcium did not alter beef tenderness, live animal performance, or carcass measurements.

Key Words: calcium, zilpaterol hydrochloride, beef tenderness

0685 Optimizing phosphorus utilization by dairy cows. J. C. Plaizier*, K. H. Ominski, and E. J. McGeough, *University of Manitoba, Winnipeg, Canada.*

A survey was conducted on 10 dairy farms in Manitoba to quantify factors that affect the utilization of phosphorus (P) by lactating cows. Farms were visited once to collect samples and data, including days in milk (DIM), milk yields (MY), parities (PAR), body condition scores (BCS), and body weights from 30 Holstein cows in different stages of lactation. Feeds were analyzed for crude protein (CP), fat (FAT), ash (ASH), NDF,

starch (STARCH), P (DIETP) and acid insoluble ash (AIA). Feces were collected from the rectum and analyzed for P (FECALP) and AIA. Composite milk samples were analyzed for fat (MFAT), protein (MPROT), and P (MILKP). The apparent digestibilities of P (ADCP) of cows were determined using AIA as a marker. Dry matter intake was estimated using the equation of NRC(2001). The P utilization efficiencies (PEFF) of cows were determined as the ratio between the output of P in milk and the P intake. Descriptive statistics (Table 0685) show the considerable variation of parameters among cows. Examination of dietary and fecal P concentrations and measures of P utilization suggested that approximately half of the cows received more P than required. Linear regression models were developed between dependent variables (FECALP, PEFF, ADCP) and independent diet and cow variables. Independent variables with a significance level greater than 0.25 were stepwise removed.

Regression models were:

$$ADCP = -152.9 + 1.00 \times PAR - 2.06 \times MFAT + 2.22 \times CP + 3.63 \times FAT + 1.18 \times ASH + 2.52 \times NDF + 114.06 \times DIETP \ (R^2 = 0.39)$$

$$PEFF = 45.91 - 0.45 \times PAR - 0.04 \times DIM + 0.34 \times MY - 2.64 \times MFAT + 313.80 \times PMILK - 82.37 \times DIETP \ (R^2 = 0.79)$$

$$FECALP = 1.21 + 0.0005 \times DIM + 0.03 \times CP - 0.10 \times FAT + 0.06 \times ASH - 0.01 \times STARCH - 0.04 \times NDF \ (R^2 = 0.25)$$

Correlations among independent variables, including PDIET and other dietary variables, complicated assessing relationships between variables. The models show the complexity of factors that determine the efficiency of P for milk production, and generally suggest that this efficiency decreases in later stages of lactation when and milk yield decreases and diets are formulated accordingly.

Key Words: phosphorus, efficiency, dairy

Table 0685. Descriptive statistics

	Average	SD	Min.	25th perc.	50th perc.	75th perc.	Max.
PAR	2.37	1.41	1	1	2	3	8
DIM	170	97	15	74	166	259	464
Milk yield, kg/d	35.6	9.0	9.5	28.7	34.4	41.3	65.1
Milk P, %	0.09	0.07	0.07	0.09	0.09	0.10	0.11
Milk P eff., %	34.6	8.3	16.1	28.3	33.3	39.5	61.4
CP, %DM	16.9	0.9	15.1	16.4	16.8	17.6	18.3
NDF, %DM	34.1	3.6	29.7	30.7	33.8	35.8	41.0
P, %DM	0.41	0.04	0.34	0.37	0.41	0.45	0.47
Feces P, %DM	0.70	0.19	0.30	0.55	0.69	0.83	1.28
ADC P, %	35.1	13.2	15.9	24.0	31.7	48.1	59.7

0686 Effect of supplementary copper source on copper status in growing beef heifers offered a diet naturally high in copper antagonists. S. J. Whelan[1], T. M. Boland[1], V. P. Gath[2], J. C. Jacquier[1], and K. M. Pierce[*1], *[1]School of Agriculture and Food Science, University College Dublin, Ireland, [2]School of Veterinary Medicine, University College Dublin, Belfield, Ireland.*

The bioavailability of Cu sources fed to ruminant animals has been the subject of many research articles due to its essentiality in bodily processes and the complexities between Cu and other minerals such as Mo, S, and Fe, rendering Cu unavailable to the animal. As many of these complexes occur within the rumen, an attractive method of improving Cu bioavailability is to offer Cu sources which bypass the rumen digestive process and are subsequently digested and absorbed in the abomasum and small intestine, respectively. This experiment evaluated the effect of three Cu sources on animal Cu status where diets naturally high in antagonists are fed. Sixty beef heifers (*Bos taurus*) were used in a randomized block design based on liver Cu content and offered one of four dietary treatments (n = 15). These were: Control (Con), $CuSO_4$, Bioplex (Bio), and a novel Cu complex (NCu). The Con contained 20 mg Cu/kg DM whereas the other diets contained 54 mg Cu/kg DM. Animals were offered their basal diet of grass silage and concentrate (minerals: Fe, Cu, Mo, and S at 703, 17, 5, and 1400 mg/kg DM). Treatments were fed individually on a daily basis while blood sampling and weights were taken on a weekly basis with a liver biopsy harvested at the beginning (d −7) and end (d 56) of the trial. There was no effect of treatment on live weight (404 kg, P = 0.77). However, animals offered NCu gained more weight (+ 0.18 ± 0.11 kg/d, P = 0.03) than those offered Con. Similarly, liver Cu at d 56 was higher (+132.5 ± 25 mg/kg DM, $P < 0.01$) for animals offered NCu than those offered Con; animals offered Bio and $CuSO_4$ were not different from other treatments. Plasma Cu levels were in the normal biological range for cattle and were lower in Bio supplemented animals compared to other groups (-0.16 ± 0.03 mg/L, $P < 0.01$). Similarly, caeruloplasmin was within the normal range for cattle but was higher for animals offered $CuSO_4$ than those offered Bio (+3.41 ± 0.85 U/ml, $P < 0.01$). These results suggest that animals offered Con may have mobilized liver Cu to maintain Cu homeostasis in the blood as measured by caeruloplasmin and plasma Cu. The NCu complex gave the highest liver Cu concentration and weight gain, demonstrating the role of rumen protection of Cu in improving Cu bioavailability and animal performance.

Key Words: copper

0687 Evaluation of liver mitochondrial oxygen consumption of lactating Holstein dairy cows supplemented with Cobalt, Copper, Manganese and Zinc in organic and inorganic forms. G. Acetoze*[1], J. Champagne[2], J. J. Ramsey[3], A. M. Gehman[4], K. A. Dawson[5], and H. A. Rossow[6], *[1]University of California–Davis, Tulare, [2]VMTRC–UC Davis, Tulare, [3]University of California–Davis, Davis, [4]Alltech, Inc., Nicholasville, KY, [5]Center for Animal Nutrigenomics and Applied Animal Nutrition, Alltech, Nicholasville, KY, [6]VMTRC, University of California, Tulare.*

Production of reactive oxygen species (ROS) at mitochondrial level may cause membrane damage impacting energetic efficiency by yielding less ATP. The objective of this study was to evaluate the impact of different concentrations of organic and inorganic forms of Co, Cu, Mn, and Zn (Bioplex Co, Cu, Mn, and Zn; Alltech, Inc.) on liver mitochondrial respiration of lactating dairy cows at a commercial dairy. Fifty lactating Holstein dairy cows (70 DIM) were randomly assigned to five treatments: Control, Organic75, Organic100, Organic125, Inorganics ($CuSO_4.5H_2O$, $MnSO_4.H_2O$, and ZnSO4.H_2O supplemented at the same amount as Organic100) (Table 0687). Minerals were supplemented on top of control diet to individual cows daily with an oral solution of the mineral for 28 d (24 d for adaptation and 4 d of sample collection). On the last day of treatment, 1 g of liver tissue was biopsied to measure O_2 consumption in isolated mitochondria. Statistical analysis was performed in R (version 2.15.1) using ANOVA. State 3 respiration (maximum ATP stimulated respiration), State 4 respiration (maximum leak-dependent respiration), and respiratory control ratio (RCR = State 3/State 4) did not differ among treatments ($P = 0.72$, $P = 0.38$, and $P = 0.76$, respectively), which may be related to high variation in mitochondrial respiration among cows. Numerically, Organic100, 75, and inorganics had the greatest oxygen consumption for ATP production and the greatest rates of oxygen consumption during proton leak dependent respiration. If only considering oxygen consumption results, greater mitochondrial efficiencies would be expected for cows with less oxygen consumption during State 4 and greater oxygen consumption during State 3 respiration. In the present study, supplementation of Co, Cu, Mn, and Zn in Organic125 and control cows had the least oxygen consumption during State 4 respiration, however data on individual cow's feed intake may change these results. Concentration of minerals for Organic125 could be acting as antioxidants by decreasing the incidence of ROS and protecting mitochondria from oxidative damage. Limiting oxidative damage by feeding greater concentrations of antioxidants may prevent mitochondrial membrane damage increasing the efficiency of ATP production and potential increase on milk production and feed efficiency.

Key Words: dairy, mitochondria, minerals

Table 0687. Amount of minerals supplemented on top of control diet for each treatment

	Control	Organic75	Organic100	Organic125	Inorganics
			(mg/d)		
Co	2.96	14.70	19.60	24.50	19.60
Mn	354.00	125.07	166.76	208.45	166.76
Cu	472.00	215.07	286.76	358.45	286.76
Zn	1409.00	375.88	501.18	626.48	501.18

0688 Cobalt-lactate inclusion in a high forage total mixed ration fed to late lactation dairy cows. J. P. Pretz*[1], H. T. Purvis[2], D. Davis[2], B. Trautman[2], J. L. Anderson[1], K. F. Kalscheur[1], and D. Casper[1], *[1]South Dakota State University, Brookings, [2]Ralco Nutrition, Marshall, MN.*

Cobalt-lactate is a highly soluble source of Co in the rumen. Prior research evaluating higher Co feeding rates has been shown to increase ruminal fiber digestion. Feeding high forage rations to late lactation dairy cows to improve income over feed cost could potentially benefit from feeding higher ruminal soluble Co rates to enhance ruminal fiber digestion and nutrient digestibility. Twenty-four late-lactation (238 ± 68.8 DIM and 36.5 ± 5.4 kg milk) Holstein dairy cows (10 primiparous and 14 multiparous), were blocked by milk yield, DIM, and parity and randomly assigned to one of two treatments. Treatments included: 1) CONTROL diet containing cobalt carbonate fed at 58 mg/cow/d, and 2) TEST diet being the same basal diet but including an additional 5 g/cow/d of a 1% Co-lactate product (Co-Max) to increase levels of cobalt by 50 mg/cow/d. Rations were 70% forage and 30% of the respective experimental grain mix on a DM basis with the forage blend consisting of 60% alfalfa baleage and 40% corn silage (DM basis). Cows were fed the CONTROL ration during the covariate period of 7 d followed by 4 wk of data collection when CONTROL and TEST diets were fed. Milk production (26.2 and 25.8 kg/d for CONTROL and TEST, respectively throughout results) was similar ($P = 0.72$). Dry matter intakes (22.9 and 23.1 kg/d) were similar ($P = 0.8$). Concentration of milk fat (4.13 and 4.13%), milk protein (3.53 and 3.40%), and lactose (4.68 and 4.71%) were similar ($P = 0.98$, $P = 0.21$, and $P = 0.66$, respectively). Body weights (684 and 673 kg) were not different ($P = 0.11$). Feeding additional Co as cobalt-lactate did not influence milk production, milk composition, dry matter intake, or body weight for lactating dairy cows fed a high forage ration.

Key Words: dairy cattle, cobalt-lactate, high-forage diet

0689 Supplemental trace minerals (Zn, Cu, and Mn) as sulfates, organic amino acid complexes, or hydroxy trace mineral sources for shipping-stressed calves. A. W. Ryan*[1], E. B. Kegley[1], J. Hawley[1], J. A. Hornsby[1], J. L. Reynolds[1], and S. B. Laudert[2], [1]*Dep. of Animal Science, University of Arkansas Div. of Agriculture, Fayetteville,* [2]*Micronutrients, Indianapolis, IN.*

The objective of this study was to evaluate the effect of trace mineral supplementation from sulfate, organic amino acid complexes, or hydroxy sources on growth performance, morbidity and immune response to bovine viral diarrhea (BVD) vaccination in newly received stocker cattle. Crossbreed calves (n = 350; average BW = 240 ± 1 kg) were obtained from regional livestock auctions. Within each arrival set (block, n = 4), calves were stratified by BW and sex, and allocated into one of eight pens (10 to 12 calves/pen). Pens were assigned randomly to one of three treatments consisting of supplemental Zn (360 mg/d), Cu (125 mg/d), and Mn (200 mg/d) from sulfate (n = 2 pens/block), organic complexes (Availa4, Zinpro Corp., Eden Prairie, MN; n = 3 pens/block), or hydroxy (IntelliBond, Micronutrients, Indianapolis, IN; n = 3 pens/block) trace mineral sources fed over a 42- (block 4) to 45-d (blocks 1, 2, 3) backgrounding period. Cattle were observed daily for signs of morbidity from bovine respiratory disease (BRD) and treated according to a preplanned protocol if rectal temperature exceeded 40°C. Serum samples for BVD antibody titer analysis were obtained on d -1, 14, 28, and final day from the calves in 2 blocks (n = 175). Data were analyzed using the PROC MIXED of SAS with treatment as a fixed effect, block as a random effect, and pen as the experimental unit. When dead (n = 1) and chronic (n = 6) calves were removed from the dataset, final BW did not differ among treatments (280 ± 4 vs. 283 ± 3 vs. 280 ± 3 kg for sulfate, organic complexes, and hydroxy, respectively; P > 0.55) or ADG (0.94 ± 0.05 vs. 0.99 ± 0.04 vs. 0.93 ± 0.04 kg for sulfate, organic complexes, and hydroxy, respectively; P = 0.51). For all calves, dietary treatments had no effect on the number treated once (P = 0.93), twice (P = 0.71), or three times (P = 0.53) for BRD, or on the number of calves classified as chronic (P = 0.55). Trace mineral source had no effect (P = 0.78) on average medical cost per calf. Antibody titer response to BVD vaccination was not affected by trace mineral source (treatment × day, P = 1.00). Based on results from this experiment, source of trace mineral supplementation did not affect total weight gain, ADG, morbidity, medical costs, or antibody titer response to BVD vaccination during the receiving phase in shipping stressed calves.

Key Words: beef cattle, trace mineral

0690 Effect of inorganic or organic selenium supplementation during gestation and lactation on cow and pre-weaning calf performance. C. R. Muegge*[1], K. M. Brennan[2], R. P. Lemenager[1], and J. P. Schoonmaker[1], [1]*Purdue University, West Lafayette, IN,* [2]*Alltech Inc., Nicholasville, KY.*

Angus x Simmental cows (n = 48, BW = 594 kg, BCS = 5.26, Age = 2.7), pregnant with male fetuses, were used to determine the effect of selenium (Se) source during the last 80 d of gestation and first 105 d of lactation on cow and calf performance. At 203 d in gestation, cows were allotted to one of three treatments based on body weight, breed composition, and calf sire: no Selenium, organic Se, or inorganic Se. Diets contained corn silage, corn stover, haylage, dried distiller grains solubles, and mineral and were formulated to contain 10.4% CP and 0.90 Mcal/kg NEg during gestation and 12.1% CP and 1.01 Mcal/kg NEg during lactation. Diets were fed daily as a total mixed ration and none, 0.30 mg/kg Se as sodium selenite, or 0.30 mg/kg Se as Sel-Plex were top-dressed daily. Treatment diets were fed through 105 d post-partum (DPP). At 105 DPP cow-calf pairs were commingled until weaning at 210 DPP. At 68 DPP milk production was calculated using the weigh-suckle-weigh procedure, and a milk sample was collected to determine composition. Cow weight and BCS and calf birth weight did not differ at the beginning of the trial ($P \geq 0.55$). Cow BW and BCS ($P \geq 0.85$) did not differ between treatments at any time point during the study. Milk production, milk fat %, and total solids % ($P \geq .38$) did not differ among treatments. Milk protein % tended to increase in the inorganic Se diet compared to organic Se diet (P = 0.07) and milk lactose % tended to be greatest in the organic Se cows (P = 0.10). Conception to AI and overall pregnancy rates did not differ between the diets ($P \geq 0.39$). Calf weights and ADG did not differ for the 105 d experimental period ($P \geq 0.77$) or for the entire pre-weaning period ($P \geq 0.33$). In conclusion, dietary Se source did not affect cow performance, milk production, or reproductive ability. Organic Se decreased milk protein and increased milk lactose, but did not alter pre-weaning performance of the progeny.

Key Words: beef, cow/calf, selenium

0691 Effects of calf age at weaning on cow and calf performance and feed utilization in an intensive production system. J. M. Warner*[1], K. H. Jenkins[2], R. J. Rasby[1], M. K. Luebbe[2], G. E. Erickson[1], and T. J. Klopfenstein[1], [1]*University of Nebraska, Lincoln,* [2]*University of Nebraska, Scottsbluff.*

A 2-yr experiment compared the feed utilization of producing a weaned calf to 205 d of age between early and normal weaning in an intensive beef cow-calf production system. Multiparous, crossbred (Red Angus x Red Poll x Tarentaise x South Devon x Devon), lactating beef cows (n = 163) with

summer-born calves at side were blocked by prebreeding BW (H, M, L), stratified by calf age and assigned randomly to one of four treatments within strata. The experiment was a randomized complete block design with a 2 × 2 factorial arrangement of treatments with three replications (pens) per treatment per year (total $n = 24$). Treatment factors were: 1) location: eastern (ARDC) or western (PHREC) Nebraska, and 2) calf age at weaning: 91 ± 18 (EW) or 203 ± 16 (NW) d of age. Regardless of location, EW cows and calves and NW pairs were fed a common diet (60:40 distillers grains:crop residue [yr 1]; 40:40:20 corn silage:distillers grains:crop residue [yr 2], DM basis) from the time of early to normal weaning. EW cows were limit-fed (6.9 kg DM/cow daily), while EW calves were offered ad libitum access to feed (4.0 kg DM/calf daily). NW pairs were limit-fed the equivalent amount of DM consumed by EW cows and calves (10.8 kg/pair daily). All cattle were managed in earthen feedlot pens, with pen serving as the experimental unit. By design, BW and BCS at early weaning were similar ($P \geq 0.27$) between EW and NW cows. At normal weaning time, EW cows had greater BW than NW cows, and BW change from early to normal weaning was 17 kg greater ($P \leq 0.01$). Cow BCS at normal weaning time was not impacted ($P = 0.42$) by weaning management. Likewise, calf age at weaning had no impact on BCS change. As intended, calf BW at the time of early weaning was not different, but remained similar ($P = 0.38$) at normal weaning time. NW and EW calves gained 0.85 and 0.82 kg daily, respectively. Similar feed energy intake resulted in comparable performance between weaning regimens. These data indicate early weaning has minimal effect on reducing the feed energy needed to maintain a cow-calf pair. Thus, decisions regarding early weaning should be made on the basis of management rather than feed efficiency.

Key Words: cow, efficiency, weaning

0692 Can treatments of barley grain with lactic and citric acid improve performance of male calves?

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Thirty Holstein male calves with an initial body weight 308 ± 22 Kg were used in a completely randomized design with 3 treatments and 10 replicates in each treatment for 100 d. Rolled barley grain steeped in an equal quantity (i.e., in a ratio of 1: 1, wt/vol) of either tap water alone, 0.5% lactic acid solution, or 1% citric acid solution was added to rations. Therefore, dietary treatments included: 1) control (with rolled barley), 2) rolled barley treated with citric acid, and 3) rolled barley treated with lactic acid. The rations were formulated according NRC beef (1996) guidelines. Calves were housed in tie stalls and fed individually. Dry matter intake was measured daily, and weight gain was measured every 4 wk. All of data were analyzed with PROC MIXED of SAS. Final body weight differed across treatments ($P < 0.05$) being 424, 439, and 442 kg to the treatment 1, 2, and 3, respectively. Average daily gain was greater in treatment 2 and 3 vs. 1 ($P < 0.05$, 1.30, 1.48, and 1.50 kg/d, respectively). Dry matter intake was not different among treatments. Gain-to-feed ratio increased due to lactic or citric acid treatment compared with control ($P < 0.05$; 0.162, 0.167, and 0.144, respectively). Overall, feeding feedlot cattle with rolled barley grain treated with lactic or citric acid improved growth performance of calves.

Key Words: barley treated with acid, feedlot cattle, performance

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0693 Starter crude protein concentrations on growth and intake of dairy calves.

S. A. McCullough[1], B. Houin[2], and T. D. Nennich[*1], [1]*Purdue University, West Lafayette, IN,* [2]*Homestead Dairy, Plymouth, IN.*

The objective of this study was to determine the effects of starter CP levels on growth, intake, feed efficiency, and plasma urea nitrogen (PUN) concentrations of dairy calves on a commercial dairy. In this randomized complete block design, 120 Holstein heifers (BW = 40.3 ± 4.9 kg) were blocked by birth date. Heifers were assigned to starter CP levels of 18, 20, 22, or 24% (as fed). Calves were fed whole milk and allowed ad libitum access to starter. All calves were fed milk 3x/day and received 5.7 L/d for 14 d, 6.7 L/d from d 15 to 21, and 7.6 L/d from d 22 to 1 wk before weaning when calves were reduced to 1.9 L once/d. Calves were weighed at birth and measured every 3 wk for BW, hip height, heart girth circumference (HGC), and hip width. Blood samples were taken at wk 12 and analyzed for PUN. Data were analyzed as repeated measures using the PROC PROC MIXED of SAS. At 12 wk, BW was greater ($P < 0.01$) for 24% compared to 18% calves (106.9 and 101.4 kg, respectively) with 20% and 22% (103.7 and 104.1 kg, respectively) being similar to all treatments. Overall average daily gain (ADG) for 20% and 22% (0.74 and 0.75 kg/d, respectively) were similar to 18 and 24%, but 18 and 24% (0.72 and 0.78 kg/d, respectively) were different ($P < 0.05$). Starter intake over the study was similar among treatments at 0.80, 0.83, 0.87, and 0.91 kg/d for 18, 20, 22, and 24%, respectively ($P > 0.23$). Overall feed efficiency was similar ($P > 0.45$) among treatments at 1.78, 1.83, 1.92, and 2.0 kg DM intake/kg gain, respectively. Hip height and HGC were similar among treatments ($P > 0.55$), but hip widths at 12 wk were greater for 22 and 24% ($P < 0.05$). As CP levels increased from 18 to 24%, PUN concentrations increased among treatments (11.8, 13.1, 15.2, and 16.4 mg/dL, respectively; $P < 0.001$). Feeding calves increasing levels of CP in starter did not result in differences in skeletal growth, feed efficiency, or overall starter intake. At 12 wk, feeding calves 24% CP starter resulted in greater BW than feeding 18% CP, but was similar to feeding 20 or 22% CP starter. Feeding 18, 20, or 22% CP starter resulted in similar ADG.

Key Words: dairy calves, starter, protein

0694 Influence of dietary carbohydrate fractions on growth and development of prepubertal dairy heifers. T. S. Dennis*, J. E. Tower, A. M. Mosiman, and T. D. Nennich, *Purdue University, West Lafayette, IN.*

The objective of this study was to evaluate the effects of altering dietary non-fiber carbohydrates (NFC) on heifer growth, dry matter intake (DMI), feed efficiency, and blood and rumen metabolites. Ninety Holstein heifers (145.3 ± 25.4 kg, 144 ± 26 d of age) were randomly allocated by body weight (BW) to one of 15 pens. Pens were randomly assigned to dietary treatments of high NFC (HNFC; 40.7% of diet DM), low NFC (LNFC; 31.4% of diet DM) and low NFC plus fat (LNFC+; 31.9% of diet DM). Diets were formulated to be isonitrogenous, with lower calculated ME for LNFC compared with HNFC and LNFC+. Heifers were fed diets for 112 d, and forage:concentrate ratios were increased from 35:65 to 60:40 on d 57 of the study. Body weights were taken every 2 wk, and hip and withers heights, body condition score (BCS), heart girth, hip width, and blood samples were collected monthly. Rumen fluid was collected esophageally 6 h after feeding from 10 heifers/treatment (two heifers/pen) to determine pH and volatile fatty acids (VFA) monthly. Data were analyzed as repeated measures using PROC MIXED of SAS with pen as the experimental unit. Feeding LNFC+ resulted in heifers that were 4.8 kg ($P < 0.10$) and 8.8 kg heavier ($P < 0.01$) at the end of the study compared with HNFC and LNFC, respectively. Average daily gains ($P < 0.01$) and feed efficiency ($P < 0.10$) were greatest for LNFC+ from d 0 to 56; however, no treatment differences were observed from d 57 to 112. Intake as a percent of BW was greatest for HNFC (3.3%) compared with LNFC (3.1%) and LNFC+ (3.1%) throughout the study ($P < 0.01$). Heifers fed LNFC+ were taller at the hip and withers than heifers fed HNFC ($P < 0.05$) and LNFC ($P < 0.01$) on d 112. Additionally, feeding LNFC+ resulted in greater BCS compared to LNFC ($P < 0.01$), but not HNFC ($P > 0.10$). Rumen pH was lower for HNFC from d 0 to 56 ($P < 0.05$), but similar among treatments at d 84 and 112. Proportions of acetate and butyrate were least and greatest, respectively ($P < 0.01$), for HNFC from d 57 to 112. Unexpectedly, increasing dietary NFC did not improve growth compared to lower NFC diets despite increased DMI, indicating that energy availability may have greater impacts on growth than dietary carbohydrates.

Key Words: heifer, carbohydrates, growth