replicates) for 192h with or without addition of 50µM or 100µM of trans-10, cis-12 CLA or cis-9, trans-11 CLA. PGF2α was measured by radioimmunoassay in culture medium collected at 48 h intervals during culture. Culture with both isomers resulted in significant ($P < 0.001$) dose dependant ($P < 0.05$) inhibition of PGF2α secretion compared to control cultures. Treatment with trans-10, cis-12 CLA resulted in PGF2α concentrations at 48, 96, 144 and 192 h of culture of 78%, 55%, 38% and 23% of control values following treatment at 50µM and 43%, 28%, 21% and 19% of control values following treatment at 100µM. Treatment with cis-9, trans-11 CLA resulted in PGF2α concentration at 48, 96, 144 and 192 h of culture of 53%, 36%, 28% and 15% of control values following treatment at 50 µM and 21%, 12%, 7% and 8% of control values following treatment at 100 µM. The cis-9, trans-11 isomer consistently caused greater inhibition than the trans-10, cis-12 isomer. These results demonstrate that both CLA isomers significantly inhibited PGF2α secretion by uterine endometrial cells, and may have potential to improve the establishment of pregnancy in cows. Further work is required to determine whether these effects occur in vivo and to establish optimum doses.

Key Words: CLA, PGF2α, Endometrium

Ruminant Nutrition: Calves & Heifers – Dairy

589 Effects of dietary fish oil on immunocompetence of neonatal Jersey calves. M. A. Ballou* and E. J. DePeters, *University of California*, *Davis*.

Fifty-one Jersey, bull calves (4±1 day old) were completely randomized to one of three treatments to evaluate the effects of dietary fish oil on immunocompetence. Treatments differed only in the fatty acid (FA) composition of the milk replacer, which was altered by supplementing 2% of the DM with FA from various lipids. Treatments included a control with a 3:1 blend of corn and canola oils, a 1:1 mix of fish oil and the control blend, and fish oil only. Body weight, height at withers, and length between withers and pins were measured weekly. Fecal and respiratory scores were recorded multiple times daily. Peripheral blood samples were collected on d 0, 7, 14, 21, and 42; the FA composition of plasma and peripheral blood mononuclear cell (PBMC) phospholipids was measured. Immunocompetence of calves was evaluated by the ability of neutrophils and monocytes to phagocytose *E. coli* and produce an oxidative burst, the change in ear thickness following an intradermal injection of phytohemagglutinin-P (PHA–P), and the primary and secondary humoral responses to ovalbumin (OVA). Adding fish oil to milk replacer significantly altered the omega-3, omega-6, and their FA ratios in both plasma and PBMC phospholipids and the response was dose and time dependent. Production and health parameters were unaffected by treatments. There were no significant treatment or treatment*time effects on phagocytosis; however there was a significant bell–shaped response on the percent of neutrophils producing an oxidative burst (49.9, 62.8, and 50.8 %; P=0.05). Fish oil did not affect the change in ear thickness in response to PHA-P. There was also no treatment effect on the primary IgG humoral response to OVA, but there was a significant bell-shaped treatment effect on the secondary IgG response (1.06, 0.79, and 1.03 OD; P=0.01). There was no significant IgM response in any treatment following either the primary or secondary OVA vaccination. Adding fish oil to milk replacer altered various functional immune responses and the effect was bell-shaped. However, no differences in the production or health of these calves were evident.

Key Words: Calves, Fish oil, Health

590 Modifying the acute phase response of neonatal Jersey calves by supplementing milk replacer with fish oil. M. A. Ballou* and E. J. DePeters, *University of California*, *Davis*.

Fifty-one Jersey, bull calves (4±1 day old) were completely randomized to one of three treatments to evaluate the effects of dietary fish oil on the acute phase response. Treatments differed only in the fatty acid composition of the milk replacer, which was altered by supplementing 2% of the dry matter (DM) with fatty acids from various lipids. Treatments included a control with a 3:1 blend of corn and canola oils, a 1:1 mix of fish oil and the control blend, and fish oil only. On d 23 each calf was injected subcutaneously with 4 µg/kg BW of *Salmonella typhimurium* endotoxin. Clinical, hematological, and biochemical parameters were measured at 0, 1, 2, 3, 4, 5, 6, 8, 10, 12, 15, 18, 24, and 72 h. Endotoxin caused a dramatic rise in respiratory rate; feeding fish oil significantly attenuated the increase (41.4, 35.1, 34.5 breaths/min; P=0.01). Heart rate and rectal temperature were not affected by treatment. Feeding fish oil attenuated the change in serum iron concentration over time (P=0.02). There was no effect of treatment on serum glucose concentration. Endotoxin also caused acute increases in blood urea nitrogen (BUN) and non-esterified fatty acids (NEFA); there were significant linear effects of fish oil on both BUN (8.34, 8.16, and 7.70 mg/dl; P=.02) and NEFA (0.689, 0.608, 0.524 mEq/L; P=0.02). Serum triglycerides (TG) were elevated beginning at 12 h after the endotoxin challenge and returned to baseline values within 72 h. Fish oil suppressed the rise in TG during this period, and the effect was linear (52.7, 42.8, and 33.4 mg/dl; P=0.01). There was no treatment effect on serum aspartamine aminotransferase activity, but there was a tendency (P=0.10) for fish oil to increase serum lactate dehydrogenase activity. Adding fish oil to milk replacer attenuates many aspects of the acute phase response, and the effect is linear in the range of 1 to 2% of the DM as fatty acids from fish oil. Adding fish oil might provide a better balance between a necessary versus an excessive acute phase response.

Key Words: Calves, Fish oil, Inflammation

591 Sodium zeolite A supplementation to dairy calves. K. Turner*[1], B. Nielsen[2], C. O'Connor[2], D. Rosenstein[2], H. Schott[2], C. Womack[2], F. Nielsen[3], and M. Orth[2], [1]*The University of Georgia*, *Athens*, [2]*Michigan State University*, *East Lansing*, [3]*Grand Forks Human Nutrition Research Center*, *Grand Forks, ND*.

Sodium zeolite A (SZA), an aluminosilicate, has been used in animal studies, but alterations in mineral metabolism and tissue composition have not been fully investigated. The objective of this study was to determine the effects of SZA on mineral metabolism and tissue mineral composition in bull calves. At three days of age, twenty calves were placed according to birth order into one of two groups: SS, receiving 0.05% BW SZA daily in milk replacer and CO, receiving only milk replacer. Blood samples were collected on d 0, 30, and 60 for mineral analysis (Si, Al, Ca, Cu, Fe, Mg, P, Zn). Total collections of feces and urine were performed on d 30 for mineral metabolism. Calves were euthanized on d 60 and multiple tissues were harvested for mineral

analyses. Supplementation with SZA resulted in greater intakes of Si and Al (P<0.0001). There was no difference in Si absorption or retention between groups. Plasma Si concentration in both groups increased from d 0 to d 15 but decreased to below starting values on d 30 (P<0.05) and plasma Si concentration was higher in SS calves on d 15 (P<0.05). Silicon content was greater in aorta, spleen, lung, muscle, and kidney of SS calves (P≤0.05). Retention of Al was greater in SS calves (P=0.001). Despite a lack of change in plasma Al concentration in SS calves, all SS tissues analyzed had greater Al content (P≤0.05). Although there was no difference in Mg absorption or retention, plasma Mg concentration was lower and heart, kidney, liver and pancreas Mg contents were greater in SS calves (P<0.05). Phosphorus absorption tended to be lower in SS calves (P=0.09), and plasma P concentration was lower (P<0.05). However, there was no difference in P tissue mineral content. Iron was the only mineral found to be lower in SS tissues (P≤0.05), suggesting possible antagonism with Al absorption. In conclusion, SZA alters mineral metabolism and tissue mineral composition of dairy calves, presumably through interactions with Al.

592 Ruminal development in Holstein dairy calves fed distillers grains. M. Thomas*, A. R. Hippen, K. F. Kalscheur, and D. J. Schingoethe, *South Dakota State University*, *Brookings*.

To evaluate the effect of calf starters containing dried distillers grains (DDG) on rumen development, 12 Holstein bull calves (3.4 days of age, SD 2.6) were blocked by birth weight and randomly assigned to one of three dietary treatments. Diets were formulated to contain 22% CP. The control diet (Ctrl) consisted of cracked dry corn, molasses, rolled oats, 44% CP soybean meal, and vitamin and mineral supplements to meet NRC 2001 suggested requirements. The experimental diets contained 28% DDG (T1) and 56% DDG (T2) (DM-basis) respectively, with DDG partially substituting for corn, oats, and soybean meal. Calves were housed individually and fed experimental diets once daily for ad libitum consumption for 12 wk. All the calves received commercial milk replacer (CP 22%) until weaning at 7 wk of age. Calves were sacrificed at 12 wk of age at which time, rumen tissues were collected for rumen epithelial growth measurements, and ruminal fluid was collected for measuring pH and volatile fatty acids. Weight of empty rumens and intestines were recorded. The average papillae densities per cm^2 of the rumen tissue were 75.4, 117.1 and 98.7 for calves fed Ctrl, T1 and T2, respectively, with Ctrl differing from T1 ($P < 0.02$). Papillae length (0.29, 0.22 and 0.22 cm) was greater for Ctrl than T1 and T2 ($P < 0.05$). Papillae width (0.07, 0.06 and 0.06 cm) was greater for Ctrl than T1 ($P < 0.06$) and T2 ($P < 0.07$). Hence, the average surface area for papillae was greater for calves fed Ctrl ($P < 0.03$) than for those fed diets containing DDG. There was no difference in the total surface area of papillae per cm^2 of rumen tissue. The pH of the ruminal fluid (5.38, 5.28 and 5.14) was higher for Ctrl than T2 ($P < 0.03$). Empty weight of rumen were 4.6, 3.2 and 3.7 Kg with Ctrl differing from T1 ($P < 0.02$) and T2 ($P < 0.07$). There were no significant differences in rumen volatile fatty acid concentrations and weight of intestines across treatments. This study indicated that the inclusion of DDG in calf starters increased the number of rumen papillae per unit area; however the positive influence of this is diminished by decreased size and surface area of individual papillae.

Key Words: Distillers grains, Dairy calves, Rumen development

593 Effect of altering theoretical rumen degraded and metabolizable protein in a calf starter. T. Hill*, J. Aldrich, H. Bateman, and R. Schlotterbeck, *Akey*, *Lewisburg, OH*.

The objective of the trial was to compare feeding three calf starters with different concentrations of rumen degraded (RDP), metabolizable protein (MP), metabolizable lysine (MLYS), and metabolizable methionine (MMET). Most published trials that compare starters with different concentrations of MP have increased MP while reducing RDP. Additionally, RDP and MP values of feeds are based on trials in older animals. Calves were fed starters and water free choice from d 1-56. Starters were complete pellets. Starter A contained 53.9% corn, 24.25% soybean meal, 14.0% wheat midds, 2.5% molasses, and other non-protein ingredients and was 18% CP as-fed. Starter B (over 10% more MP, MLYS, MMET, but less RDP than Starter A) contained 60.9% corn, 8.45% soybean meal, 14.0% wheat midds, 4.6% blood meal, 2.5% molasses, 2.2% fish meal, 2.2% corn gluten meal, and other non-protein ingredients and was 18% CP as-fed. Starter C (equal RDP to Starter A; equal MP, MLYS, MMET to Starter B) contained 52.46% corn, 17.89% soybean meal, 14.0% wheat midds, 3.4% blood meal, 2.5% molasses, 2.4% fish meal, 2.4% corn gluten meal, and other non-protein ingredients and was 21% CP as-fed. All 48 Holstein calves from one dairy (initially 2-3 d old, 43 ± 1 kg, 5.0 ± 0.2 mg serum protein/dl) were fed 0.681 kg daily of a 26% CP, 17% fat milk replacer and weaned at 28 days. Calves were housed in a naturally ventilated nursery with no heat in individual pens bedded with straw. Data were analyzed as a completely randomized block design. Treatment means did not differ ($P > 0.1$) for gain (0.56 ± 0.02 kg), starter intake (2.11 ± 0.09 kg), gain to feed efficiency (0.40 ± 0.02), hip width change (4.0 ± 0.2 cm), body condition score, fecal score, or medical days from 0-56 d. Increasing the theoretical MP, MLYS, and MMET concentration of the starter did not change calf performance during the first two months of life, suggesting that these theoretical values for the feeds are not appropriate for young calves and/or protein fractions were not limiting gain.

Key Words: Calves, Rumen undegraded protein, Metabolizable protein

594 Effect of altering theoretical rumen undegraded soybean protein in a calf starter. T. Hill*, J. Aldrich, H. Bateman, and R. Schlotterbeck, *Akey*, *Lewisburg, OH*.

The objective of the trial was to compare feeding two calf starters with similar CP, amino acid and energy concentrations but with different amounts of undegraded soybean CP. Most published trials that compared starters with different concentrations of undegraded protein have confounded amino acid composition or other nutrients. Additionally, theoretical undegraded protein values of feeds are based on trials in older animals. Calves were fed 18% CP as-fed starters (37% corn, 35% supplement pellets, 25% oats, 3% molasses) and water free choice from d 1-56. The low undegraded protein starter contained (as-fed basis) a supplement with 68.34% soybean meal, 18% wheat midds, and other non-protein ingredients. The high undegraded protein starter contained a supplement with 63.1% modified expeller extracted soy protein (Soyplus®, Ralston, IA), 14.5% soybean meal, 9.4% wheat midds, and other non-protein ingredients resulting in over 30% more undegraded protein and over 10% more metabolizable protein compared to the low undegraded protein starter. All 48 Holstein calves from one dairy (initially 2-3 d old, 42 ± 2 kg, 5.2 ± 0.2 mg serum protein/dl) were fed 0.681 kg daily of a 26% CP, 17% fat milk replacer and weaned at 28 days. Calves were housed in a naturally ventilated

nursery with no heat in individual pens bedded with straw. Data were analyzed as a completely randomized block design. Treatment means did not differ (P > 0.1) for gain (0.55 ± 0.04 kg), starter intake (2.31 ± 0.14 kg), gain to feed efficiency (0.44 ± 0.02), hip width change (3.6 ± 0.4 cm), body condition score, fecal score, or medical days from 0-56 d. Increasing theoretical rumen undegraded protein and metabolizable protein while other nutrients in the starter were equal did not change performance during the first two months of life, suggesting that these theoretical values for the feeds are not appropriate for young calves and/or protein fractions were not limiting gain.

Key Words: Calves, Rumen undegraded protein, Starter

595 Enhanced-growth feeding program: Starter digestibility at weaning. M. Terré*[1], A. Bach[2,1], and M. Devant[1], [1]*Institut de Recerca i Tecnologia Agroalimentàries-Unitat de Remugants*, *Barcelona, Spain*, [2]*Institució Catalana de Recerca i Estudis Avan&ccedul;ats*, *Barcelona, Spain*.

Calves following an enhanced-growth feeding program usually show worse gain to feed ratio the weeks around weaning. To assess whether this decrease is due to a potentially lower capacity to digest starter after weaning of calves receiving an enhanced-growth feeding program, 19 Holstein male calves were used to determine starter apparent nutrient digestibility the week after weaning. Calves were divided in two groups: calves following a conventional feeding program (CF) and calves following an enhanced-growth feeding program (EF). After one week of adaptation to milk replacer (25% CP and 19% fat), the CF calves were fed 4 l/d of milk replacer (MR) at 12.5% DM from 1-27 d, and 2 l/d from 28-34 d, and the EF calves were offered MR at 18% DM: 4 l/d from 1-6 d, 6 l/d from 7-13 d, 7 l/d from 14-20 d, 6 l/d from 21-27 d, and 3 l/d from 28 d to weaning at 34 d of study. Calf starter (19.7% CP) was offered ad libitum from the beginning to the end of the study at 42 d, and starter consumption was recorded daily. Calves were weighed at 7, 24, 31, 38 and 42 d of study. Daily total feces collection was conducted the last 5 days of study. Final BW tended (P = 0.08) to be greater in EF than CF calves (87.9 vs 82.0 ± 1.93 kg, respectively). Starter DMI was greater (P < 0.05) in CF compared with EF calves (0.97 vs 0.64 ± 0.091 kg/d, respectively), but there were no differences in total DMI (1.46 and 1.52 ± 0.11, kg/d in CF and EF, respectively). Calves in both treatments presented similar gain to feed ratios the weeks before and after weaning. However, apparent DM, OM, NDF, and CP digestibilities were greater (P < 0.05) in CF compared with EF calves (77.4 vs 71.8 ± 1.23%, 78.6 vs 73.3 ± 1.31%, 34.7 vs 20.3 ± 3.79%, and 77.1 vs 71.6 ± 1.29%, respectively) the week after weaning. Calves in the EF treatment presented lower nutrient digestibility compared with CF calves the week after weaning, but differences in gain to feed ratio were not found in the current study.

Key Words: Calves, Weaning, Digestibility

596 Effects of an intensified compared to a moderate feeding program during the preweaning phase on long-term growth, age at calving, and first lactation milk production. L. Davis Rincker*, M. VandeHaar, C. Wolf, J. Liesman, L. Chapin, and M. Weber Nielsen, *Michigan State University*, *East Lansing*.

We previously found that increasing the energy and protein intake during the preweaning period resulted in larger and taller calves at weaning, decreased age at puberty and at conception, but also increased preweaning feed cost per kg of gain. The experimental objective was to determine if increasing the energy and protein intake from 2 d to 6 wk of age would affect long-term body growth, age at first calving, and first lactation milk yield. Holstein heifers (n = 80) born throughout the year at the Michigan State University Dairy Teaching and Research Center were assigned randomly to 1 of 2 dietary treatments (moderate, M; high, H). The M diet consisted of a standard milk replacer (21.5% CP, 21.5% fat) fed at 1.2% of BW on a DM basis and a 19.9% CP starter grain fed to achieve 0.45 kg of average daily gain (ADG). The H diet consisted of a high-protein milk replacer (30.6% protein, 16.1% fat) fed at 2.1% of BW on a DM basis and a 24.3% CP starter grain fed to achieve 0.68 kg ADG. Calves were gradually weaned by 6 wk of age and were fed and housed similarly after 8 wk of age. Withers height, BW, and hip width measurements were taken every 4 wk after the treatment period. Heifers became eligible for breeding at 397 kg BW. Age at calving was 17 d earlier for heifers fed the H diet during the preweaning period (P = 0.05). Body weight taken after calving was not different and averaged 574 and 563 kg for M and H, respectively (P = 0.13, SE = 5.2). Daily gain during gestation, withers height at calving, BCS at calving, calving difficulty score, and calf BW were not different (P > 0.4). Average daily milk yield for the first 60 DIM was 30.5 kg for both treatments (P > 0.9). Intensified feeding programs during the preweaning phase is one way that producers can decrease age at first calving without causing detrimental effects on milk yield. Collection of milk production and health data through 150 DIM and economic analyses are ongoing.

Key Words: Calf, Nutrition, Milk replacer

597 The effects of restricted feeding high concentrate or high forage rations on rumen fermentation in dairy heifers. G. I. Zanton* and A. J. Heinrichs, *The Pennsylvania State University*, *University Park*.

Feeding dairy heifers represents a balance between providing the precise nutrient requirements for maintenance and growth while minimizing the costs associated with meeting these nutrient requirements. Although a majority of the required nutrients are provided by forages in most dairy heifer rations, replacing the nutrients from forages with concentrates holds the potential to increase the efficiency of raising dairy heifers by lowering feed costs, improving metabolic efficiency, and reducing manure output. The objectives of this experiment were to evaluate rumen fermentation in dairy heifers fed a high concentrate (**HC**) or a high forage (**HF**) ration at two 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 rumen cannulated heifers per block for four, 28d periods. Rumen contents were sampled over d22-23 and removed on d14 and 28. Both the HC and the HF rations contained the same feeds, but in differing proportions, yielding two treatment rations containing 75 or 25 percent of the ration dry matter as forages (corn silage, grass, and alfalfa hay). The treatment rations were fed restrictedly to provide 0.22 Mcal ME and 1.9 g N per kg $EBW^{0.75}$. The heifers fed HF had increased total rumen content wet weight (37.84 HC vs. 42.18 HF ± 1.36kg; $P<0.01$). Total VFA concentrations were not altered by dietary treatment (110.80 HC vs. 112.87 HF ± 5.00 mM; $P>0.14$). Similar concentrations of total VFA occurred due to higher acetate concentrations, lower butyrate concentrations (both $P<0.01$), and a tendency for reduced propionate concentrations ($P>0.07$) in HF. Mean rumen pH was lower for HC (6.24 HC vs. 6.51 HF ± 0.10; $P<0.01$) and the amount of time that the pH was lower than 6.00 was greater in HC (7.12 HC vs. 3.15 HF ±

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