ing the potential of cocoa husk mucilage (CHM) as an alternative feed resource to AGLS. 144 AGLS with weight ranging from 20g-45g were used for this study. The experimental snails were allotted into 4 treatments and 3 replicates. Treatments included; 100% PPF (fresh pawpaw leaf) (control), 100% ORP (fresh orange pulp), 100% KNT (fresh kolanut testa) and 100% CHM. This experiment was designed to be completely randomized. Results from the performance assessment of experimental snails showed significant differences ($P<0.05$) in average total weight gain, average total shell length increment, average total shell width increment, average total aperture radius increment. The values of average total weight gain, total average shell length increment, total average shell width increment and total average aperture radius increment were ranked as follows: PPF>CHM>KNT>ORP; PPF>CHM>ORP>KNT; CHM>PPF>ORP>KNT and PPF>ORP>CHM>KNT respectively. Results of carcass analysis showed the dressing percentage of snails fed PPF as 38.46%, ORP 36.9%, KNT, 27.16% and CHM, 33.68%. Statistical analysis showed significant differences ($P<0.05$) in scores for flavour, tenderness and overall acceptability. Average scores for overall acceptability were 7.4 for PPF, 6.9 for ORP, 5.5 for KNT and 6.1 for CHM. Values can therefore be ranked as PPF>ORP>CHM>KNT. Although the cocoa-husk mucilage had lower yield in terms of carcass than PPF and ORP, the study revealed no detrimental effect on nutrient composition of the meat samples. It could therefore be inferred that the use of cocoa husk mucilage in feeding AGL snails enhanced performance.

Key Words: fresh cocoa husk mucilage, sole feed, African giant land snails

570 Acclimation to salinity and survival of Lahontan cutthroat trout *Oncorhynchus clarki henshawi*. J. P. Bigelow*[1,2], W. M. Rauw[2], and L. Gomez-Raya[2], [1]*U.S. Fish and Wildlife Service, Lahontan National Fish Hatchery Complex*, *Reno, NV*, [2]*University of Nevada*, *Reno*.

The goal of this study was to assess the effect of acclimation to salinity on survival of Lahontan cutthroat trout reared at the Lahontan National Fish Hatchery on well water (pH=7.8; Total Dissolved Solids (TDS)=292 mg/L) and challenged with Walker Lake water (pH=9.6; TDS=17,800 mg/L). Six-month-old fish (N=2,400) were assigned to three treatments comprised of 4 replicates (tanks). Fish were acclimated for 0, 3, or 8 days by increasing the ratio of lake water to hatchery water on a daily basis. Blood was collected from fish (n=12) in each of the three tanks in the 3 and 8 day treatments prior to and after acclimation to determine plasma osmolarity(mmoles/Kg). After acclimation, a subsample (n=76) from each tank was challenged with 100% lake water for one week. Mortalities were monitored at two-hour intervals. Fish fork lengths and weights were determined at time of death or at the end of the challenge if they survived. A mixed model was used to estimate the effect of acclimation time on survival time (in hours). Other independent variables were: Fulton's Body condition factor (covariate), fork length (covariate), and tank (random effect nested within acclimation treatment). The effects of acclimation treatment, condition factor and fork length were significant with P-values of 0.048, 0.035, and <0.0001. The least square means for survival at 0, 3 and 8 acclimatizing days were 7.95±5.70, 8.06±5.69, and 28.55±5.70 hours, respectively. Only fish acclimated for 8 days survived the entire challenge experiment, but at a low rate (2.3%). A linear model using plasma osmolarity as dependent variable and acclimation time (fixed), tank (random and nested within acclimation treatment), time of blood collection (fixed), and acclimation time by blood collection time interaction (fixed) as independent variables revealed only significant results for the interaction term (P-value=0.044). Osmolarity (before and after acclimation) increased in fish acclimatizing 3 days (from 251.07 to 262.65 mmoles/Kg) but decreased in fish acclimatizing 8 days (from 258.08 to 244.01 mmoles/Kg). Implications of the results for fish repopulation are discussed.

Key Words: Lahontan cutthroat trout, salinity acclimation

Ruminant Nutrition: Dairy Calves

571 Effects of fat concentration of a high protein milk replacer on calf performance and digestion. T. M. Hill*, H. G. Bateman II, J. M. Aldrich, and R. L. Schlotterbeck, *Akey*, *Lewisburg, OH*.

Fat concentration was varied (14, 17, 20, and 23%; all units on DM basis) in a 27% CP milk replacer (MR) fed at 660 g DM/calf daily to achieve CP to ME ratios from 52 to 57 g CP/Mcal ME. The hypothesis was that high fat concentrations would reduce intake of starter, digestibility, and ADG. Forty-eight Holstein calves (initially 42.4 ± 1.5 kg BW, 2 to 3 d of age) were fed the MR (12 calves/treatment) and were weaned after 28 d. Measurements were continued from d 28 to 56. A 20% CP starter and water was fed ad libitum all 56 d of the trial. Measurements of digestion were made using chromic oxide as a marker in the MR and starter from fecal samples collected on d 19 to 23 from 4 calves/treatment. Selected serum constituents were measured on d 21. Calves were housed individually in pens bedded with straw within a naturally ventilated barn with no added heat between January and March. The barn temperature based on hourly measurements was 2°C. Data were analyzed as a completely randomized design using polynomial contrasts to separate differences in the means. Significance was declared at $P < 0.05$. Pre-weaning apparent digestibility of OM, fat, Ca, and P and serum amylase concentration were linearly reduced as fat increased from 14 to 23% in a 27% CP milk replacer powder fed at 0.660 kg DM/calf daily. Pre-weaning starter intake responded quadratically to fat, being lowest at 14 and 23% fat. A reduction in digestibility and starter intake contributed to less ADG at the higher fat concentrations in the MR. A 27% CP, 17% fat MR with 55 g CP/Mcal ME optimized ADG when fat concentration was varied from 14 to 23%.

Key Words: fat, digestion, calf

572 Effects of free-access feeding and milk replacer acidification on calf performance and development of digestive anatomy. C. G. Todd*[1], T. J. DeVries[2], K. E. Leslie[1], J. M. Sargeant[1], N. G. Anderson[3], and S. T. Millman[4], [1]*Department of Population Medicine, University of Guelph*, *Guelph, ON, Canada*, [2]*Department of Animal Poultry Science, University of Guelph, Kemptville Campus*, *Kemptville, ON, Canada*, [3]*Ontario Ministry of Agriculture, Food and Rural Affairs*, *Fergus, ON, Canada*, [4]*Veterinary Diagnostic and Production Animal Medicine, Iowa State University*, *Ames*.

The aim of this research was to examine the effects of free-access feeding and milk replacer acidification on calf performance and development of

digestive anatomy. Holstein male calves (n=16) were randomly assigned at birth to 1 of 4 feeding programs: 1) free-access (ad libitum) feeding of milk replacer (22% CP and 17% fat), 2) free-access feeding of acidified milk replacer, 3) restricted (6 L/d) feeding of milk replacer and 4) restricted feeding of acidified milk replacer. Formic acid was used to acidify the milk replacer to a target pH of 4.0 to 4.5. Milk replacer, starter ration and water intakes were measured daily, while body weight gain was determined weekly for each calf. One calf from each feeding program was euthanized at 28, 42, 56 and 70 d of age. Rumen tissue samples were collected and wall thickness, papillae length, width and density were measured. Multivariable regression models were constructed to examine the effects of free-access feeding and acidification on important outcome variables. Free-access feeding resulted in higher milk consumption (9.2 vs 5.0 L/d, $p<0.01$); acidification did not affect milk intake ($p>0.05$). Restricted-fed calves began consuming starter ration significantly earlier (HR=12.3, $p<0.01$) and had greater starter intake (3.8 vs 1.0 kg, $p<0.01$) over the free-access calves. Milk replacer acidification was associated with reduced time to initiation of starter consumption (HR=3.7, $p<0.05$). Free-access calves had higher body weight gain than restricted-fed calves (26.0 vs 14.3 kg, $p<0.05$); acidification did not affect body weight gain ($p>0.05$). Restricted-fed calves had increased rumen wall thickness ($p<0.05$), longer ($p<0.05$) and wider papillae ($p<0.05$), and reduced papillae density ($p<0.05$); acidification did not affect rumen development ($p>0.05$). These results indicate that free-access feeding of milk replacer supports improved body weight gain, but delays starter ration consumption and rumen development. Milk replacer acidification had little impact on calf performance and digestive anatomy development.

Key Words: milk replacer, free-access feeding, acidification

573 Effect of weaning age and feeding rate of a high protein calf milk replacer on diet digestibility. T. M. Hill*, H. G. Bateman II, J. M. Aldrich, and R. L. Schlotterbeck, *Akey*, *Lewisburg, OH*.

A 27% CP, 17% fat, 55 g CP/Mcal ME milk replacer (MR; all units on DM basis) was fed at 660 g DM/calf daily and calves were weaned at either 28 (Treatment A) or 42 d (Treatment B). Additionally, the same MR was fed at rates stepped up to 1090 g DM/calf daily and calves were weaned at 42 d (Treatment C). The hypothesis was that calves weaned early would gain less BW and that calves fed up to 1090 g MR would have reduced digestion of starter post-weaning. Holstein calves (initially 42.8 ± 1.5 kg BW, 2 to 3 d of age) were fed the MR (5 calves/treatment). Measurements were made through 56 d. A 20% CP starter and water were fed ad libitum all 56 d of the trial. Measurements of digestion were made using chromic oxide as a marker in the MR and starter from fecal samples collected during three time periods (P1: d 21 to 24; P2: d 36 to 39; P3: d 53 to 56). Additionally, selected serum constituents were measured on d 21, 36, and 56 to correspond with the time periods. Calves were housed individually in pens bedded with straw within a naturally ventilated barn with no added heat between July and September. The barn temperature based on hourly measurements was 24°C. Data were analyzed as a completely randomized design using pre-planned contrast statements to separate the means (A vs. B; B vs. C). Significance was declared at $P < 0.05$. During all periods, starter intake was B > C. During P2 and P3, starter intake was A > B. During P1, Ca digestibility was B > C and g of DM, OM, CP, fat and P digested was C > B. During P2, digestibility of DM, OM, fat, Ca, and P was B > A and B > C. During P3, digestibility of DM, OM, Ca, and P was B > C. During all periods, serum amylase concentration was B > C. Feeding up to 1090 (vs. 660) g MR/calf daily reduced starter intake, serum amylase concentrations, and post-weaning DM, OM, fat, Ca, and P digestibility in calves weaned at 42 d. Weaning at 28 vs. 42 d did not change post-weaning digestibility in calves fed 660 g MR/calf daily.

Key Words: fat, digestion, intake

574 Effects of weaning strategy on calf performance and health status during transition. A. Bach*[1,2], A. Ferrer[2], and J. Ahedo[3], [1]*ICREA*, *Barcelona, Spain*, [2]*Ruminant Production-IRTA*, *Caldes de Montbui, Spain*, [3]*Rancho Las Nieves*, *Mallen, Spain*.

This study aimed to assess whether continuing to offer 2 L/d of milk replacer (MR) at 15% dilution rate after moving animals from individual hutches to groups of 8 at weaning would improve animal performance and immunity, and diminish respiratory afflictions during the transition period (57 to 112 d of life). A total of 160 female Holstein dairy calves (initial BW=72±6.1 kg; age=56±3.2 d) were randomly allocated to one of 2 treatments: weaning in individual hutches (at the age of 57 d) and moved in groups of 8 (Control), or weaning 2 wk after moving (at the age of 71 d) calves from individual hutches to groups of 8 animals. When calves were moved from individual hutches to groups, they also changed diet from a starter to a dry TMR. Feed and MR consumption (by pen) was determined daily for the first 3 wk of study. Body weight was determined at the beginning and at the end of the study. Health condition was monitored daily. In addition, half of the animals in each pen were blood-sampled at 0, 14, and 21 d of the study. Pen was the experimental unit. The proportion of animals affected by respiratory problems was not influenced by treatment (44±5.6% for Control vs 35±5.4% for MR-supplemented calves). However, the number of days until the first respiratory case was greater in the MR-supplemented group (29±2.5 d) than in the Control group (19±2.2 d), and this incidence was lower in the MR-fed than in control calves during the first 4 wk of study. Average daily solid feed intake was greater in Control (3.2±0.14 kg/d) than in MR-supplemented calves (3.0±0.14 kg/d). Solid feed consumption was lower for MR-fed than for Control calves for the first 2 wk (2.6 vs 3.1 kg/d), but it was greater afterwards (3.7 vs 3.5 kg/d). The number of circulating blood lymphocytes decreased when MR was offered compared with Control (2.79±0.69 vs 3.06±0.69 x 10^3 cells/ μL, respectively). Mean platelet volume decreased in MR-fed calves compared with Control. Providing additional MR for 2 wk in groups improved ADG, but failed to sufficiently stimulate the immune system and thus diminish the incidence of respiratory problems during the entire transition period.

Key Words: pneumonia, milk replacer, immunity

575 Determination of oro-sensorial preferences for energy ingredients in weaned calves. C. Montoro*[1], F. Boe[1], I. Ipharraguerre[2], and A. Bach[1,3], [1]*IRTA-Ruminant Production*, *Caldes de Montbui, Spain*, [2]*LUCTA S.A.*, *Barcelona, Spain*, [3]*ICREA*, *Barcelona, Spain*.

The objective of this study was to determine oro-sensorial preferences among common energy feed ingredients used to manufacture calf starters. A total of 28 assays involving 280 calves were conducted to rank calf oro-sensorial preferences for: barley, corn, corn gluten feed, oats, rice, sorghum, wheat, and wheat middlings. To minimize the effect of feed texture, all ingredients were ground at 3 mm. In each assay, 20 naive calves were offered a choice ad libitum of 2 ingredients and feed consumption was monitored every 30 min for 6 h. Each assay involved a group of 20 calves, and each group was used in two different assays

which were conducted 3 and 5 d after weaning. No calf was presented twice with the same ingredient. Oro-sensorial preferences were calculated as the mean difference in feed consumption every 30 min over a 6-h period. The most preferred energy ingredients were wheat, sorghum, corn, and barley; whereas oats, rice, and corn gluten feed were the least preferred (Table 1). Wheat was the most preferred ingredient in all assays but one. On the other hand, corn gluten feed was the least preferred ingredient in all assays but one.

Table 1. Significant differences (*P*< 0.05) in consumption (g/30 min) due to oro-sensorial preferences of several ingredients

Feed1[a]	Feed2[a]	Diff.[1]	Feed1	Feed2	Diff.[1]
W	CGF	10.0	C	R	48.9
W	R	77.9	C	O	44.5
W	O	23.1	C	WM	8.6
W	WM	28.8	C	B	-12.8
W	B	16.8	B	CGF	9.9
W	S	44.2	B	R	59.3
S	CGF	3.5	B	O	66.1
S	R	33.4	B	WM	-16.5
S	O	42.3	WM	CGF	19.5
S	B	21.0	WM	R	19.7
S	C	12.8	WM	O	-55.3
C	CGF	47.4	R	CGF	12.1

[1] Feed1 - Feed2; [a]C = Corn; B = Barley; CGF = Corn gluten feed O = Oats; R = Rice; S = Sorghum; W = Wheat; WM = wheat middlings

Key Words: palatability, preferences, intake

576 High dietary iron negatively impacts gene products important in iron and manganese metabolism in young calves. S. L. Hansen*, M. S. Ashwell, R. S. Fry, and J. W. Spears, *North Carolina State University*, *Raleigh*.

Fourteen weaned Holstein calves were used in a 56-d experiment examining the impacts of high dietary iron (Fe) on proteins involved in Fe and manganese (Mn) metabolism. Calves were stratified by weight and randomly assigned to one of two diets: 1) no supplemental Fe (normal Fe) or 2) 750 mg supplemental Fe/kg DM (high Fe). Blood was collected on d 0, 35 and 56. At the end of the trial 6 calves per treatment were harvested and liver and duodenal scrapings were collected for analysis. Feeding a diet high in Fe decreased ($P < 0.05$) average daily gain, dry matter intake and feed efficiency. Hemoglobin and serum Fe concentrations did not differ due to dietary treatment. Feeding a diet high in Fe increased concentrations of Fe in the liver ($P = 0.03$), but did not affect heart or duodenal Fe. Duodenal Mn concentrations were lowered ($P = 0.05$) by feeding a high Fe diet, but liver and heart Mn concentrations were not affected. As determined by real-time RT-PCR, relative hepatic expression of the gene which encodes the Fe regulatory hormone hepcidin was 5-fold greater ($P < 0.01$) in calves fed high dietary Fe. Hepcidin is released in response to increased Fe status and binds to the Fe export protein ferroportin causing it to be degraded, thereby reducing dietary Fe absorption. Confirmation of this result was achieved through Western blotting of duodenal protein which revealed that expression of ferroportin was decreased ($P = 0.03$) due to high dietary Fe. Duodenal expression of divalent metal transporter 1 (DMT1), a Fe import protein which can also transport Mn, tended (P = 0.13) to be reduced by high dietary Fe. In summary, feeding calves a diet high in Fe induced a signal cascade (hepcidin) designed to reduced absorption of Fe (via reduced expression of ferroportin and DMT1) in a manner similar to that reported in rodents. Additionally, reduced levels of DMT1 protein appeared to decrease duodenal Mn, suggesting that Mn is also a substrate for DMT1 in the bovine.

Key Words: cattle, iron, manganese

Ruminant Nutrition: Rumen Microbiology

577 Metagenomics analysis reveals shifts in functional profiles and population dynamics of rumen microbial communities in response to developmental and dietary changes. R. W. Li*[1], M. E. Sparks[1], Y. Huang[2], W. Li[2], E. E. Connor[1], R. L. Baldwin VI[1], C. Li[1], and T. Sonstegard[1], [1]*Unisted States Department of Agriculture, Agricultural Research Service, Bovine Functional Genomics Laboratory*, *Beltsville, MD*, [2]*University of California*, *San Diego*.

Physiologists have long attempted to manipulate rumen fermentation to enhance fibrolytic capacity and reduce proteolytic and methanogenic outputs of the rumen ecosystem. However, successful ruminal fermentation manipulation requires a solid understanding of rumen microbes and their interactions. ~8 gigabases of DNA from 6 metagenomes were generated using next-generation technologies. ~70% of short reads could be assembled into contigs using Velvet. ORFs were predicted using MetaGene, and resultant proteins were annotated using Pfam, TIGRfam and COG. Higher level metagenome features, such as phylogenetic profiles, functional compositions and population dynamics, were compared between relevant rumen microbial communities. For example, 34,948 and 14,700 proteins identified from 2 of the 6 communities studied (#911 and #103) belong to roughly the same number of Pfam protein families (1,983 and 1,835, respectively), of which ~80% were identical. Interestingly, 414 protein families were unique to #911 (from calf fed hay) while 266 families unique to #103 (from calf fed milk only). Thus, differences in biological functions and ecosystem outputs may be deduced. Both glycoside hydrolase (GH) families 70 and 42 were unique to #911, suggesting ruminal degradation of cellulose and xylans as a primary function of this community. One of the most abundant families was GH family 43, which contains arabinase activities for degradation of plant cell wall arabinan, reflecting more active fibrolytic activities in #911. Moreover, unique expression of >12 other GH families in the #911 community demonstrates its character for glycosidic bond hydrolysis. In contrast, Proteobacteria were abundant in #103, as evidenced by its unique expression of cytochrome cbb3 oxidases exclusive to this phylum. Many protein families typical of aerobic prokaryotes were also abundant in this community. In addition, #103 expressed proteins involved in N metabolism, such as a urea transporter and urease, which can be advantageous due to roles NH3 plays in microbial growth and maintaining rumen pH.

Key Words: metagenomics, rumen, microbial

578 pH dynamics and bacterial community composition in the rumen of lactating dairy cows. A. Palmonari*[1], D. M. Stevenson[2],