than NC cows in all trials (June: 39.1 vs. 39.6; July: 39.1 vs. 39.3; August: 38.9 vs.39.2°C). Daily diurnal ranges and partial differences were lower for MYCW than NC cows in June (1.13 and 0.64 vs. 1.40 and 0.84°C; $P < 0.05$) and August (1.11 and 0.54 vs. 1.29 and 0.70°C; $P < 0.05$). Although not statistically significant, temperature differences between MYCW and PC cows also tended to support MYCW supplementation as a potential means of alleviating the problem of elevated body temperature associated with fescue toxicosis.

**Key Words:** Temperature, Fescue, Cows

**412 Comparison of an early weaning management system with a conventional weaning system on cow and calf performance while grazing tall fescue pastures.** C. L. Schultz*, D. G. Ely, B. T. Burden, D. K. Aaron, and J. Wyles, *University of Kentucky, Lexington, KY.*

Twenty-four, Angus x Beefmaster 2-yr-old heifers and their calves were used in a completely randomized design to compare cow and calf performance in two management systems. In the early weaning (EW) system, calves were weaned at 100 d (May 21) to fescue pastures and supplemented with a concentrate mix. Calves in the normal weaning (NW) system grazed fescue pastures with their dams until weaning at 210 d. Twelve EW calves and 12 NW cow/calf pairs were allotted to eight pastures on June 6 with four pastures per treatment. Cow and calf weights and cow BCS changes were measured at 28-d intervals from May 21 (EW) to September 4 (NW). Cow gain, from EW to NW, was greater ($P < 0.05$) for cows with EW calves (50.5 vs. -3.2 kg). Cows with EW calves gained .5 BCS; those with NW calves lost .5 BCS ($P < 0.05$). Calf gains were not different (.88 vs. .83 $kghd^{-1}d^{-1}$; EW vs. NW). To determine DMI and nutrient digestibility, steers in each pasture were dosed with n-alkane boluses on June 18, July 20, and August 20 [Period (P) 1, 2 and 3, respectively]. Fecal grab samples were collected once daily from d 10 through d 14 post-bolus. Total DMI was similar in P1 and 2, but EW calves consumed more ($P < 0.01$) during P3. Although forage DMI was greater ($P < 0.01$) for NW calves during P1 and 2, CP intake was greater ($P < 0.05$) for EW calves in P1. Intake of NDF and ADF was greater for EW calves during P3. Digestibility of DM and CP was ($P < 0.10$) higher in the NW treatment in P1 and 2 and digestibility of NDF and ADF was greater ($P < 0.08$) for NW calves during all periods. These data indicate weaning beef calves at 100 d can improve cow gains and condition, but calf gains from fescue pasture are not increased because neither dietary intake nor nutrient digestibility are increased above that of NW calves.

**Key Words:** Gain, Dry Matter Intake, Digestibility

**413 Evaluation of four ractopamine use programs on pig growth and carcass characteristics.** S.A. Trapp*, J.P. Rice, D.T. Kelly, A. Bundy, A.P. Schinckel, and B.T. Richert, *Purdue University, West Lafayette, IN.*

Barrows (n=143) and gilts (n = 149) were used in a six week study evaluating different ractopamine use programs for late finishing pigs. Pigs were allotted by weight (Initial BW = 70.8 kg), sex and ancestry to one of five ractopamine (RAC) treatments (trt): 1) control, no RAC; 2) 5 ppm RAC wk 0-6; 3) 5 ppm RAC wk 0-4, 10 ppm RAC wk 5-6; 4) 5 ppm RAC wk 0-3, 10 ppm RAC wk 4-6; 5) 5 ppm RAC wk 0-2, 7.5 ppm RAC wk 3-4, 10 ppm RAC wk 5-6. Barrows were fed a 1.1% Lys diet and gilts were fed a 1.2% Lys diet. Pigs fed RAC had increased ADG (1089 vs 984 g/d; P<.002) and increased G:F (.390 vs .363 P<. 03) compared to the control trt during wks 0-2. RAC trts during weeks 2-6 had greater ADG (911, 969, 1015, 1041, 1003 g/d; trt 1-5 respectively, P<.05) than the control trt. Pigs fed trt 4 had greater ADG (P<.02) than trt 2 during wk 2-6. Overall, pigs fed RAC had increased ADG (936, 1015, 1033, 1083, 1008 g/d; trt 1-5 respectively, P<.01) and G:F (.359 vs .324; P<.001) compared to pigs fed control, with no significant differences in ADFI among trts. Pigs fed trt 4 had greater overall ADG (P<.05) than the other RAC trts. Pigs fed RAC had increased final BW (110, 113.5, 114.2, 116.2, and 112.7 kg; trt 1-5 respectively, P<.01) and trt 4 had greater (P<.05) final BW than the other RAC trts. Pigs fed RAC had increased hot carcass weight (83.0 vs 87.5 kg; P<.001) and yielded greater dressing percent (76.41% vs 75.40%; P<.02) than the control trt. Loin eye area (LEA) was greater for pigs fed RAC (41.0, 43.2, 43.9, 44.2, 43.2 $cm^2$; trt 1-5 respectively, P<.01) than the control trt. No significant differences in backfat measurements were found among trts. All RAC use programs increased pig growth rate and feed efficiency. The RAC step up programs sustained the RAC growth response during weeks 5 and 6 better than constant level of RAC. However, the 3 wk-3 wk RAC program with levels of 5 and 10 ppm, respectively, had the greatest increase in pig growth rate and provides an effective step-up program that will maximize pig performance while using RAC.

**Key Words:** Ractopamine, Pig, Growth

## Ruminant Nutrition
## Feed Additives and Fiber

**414 Use of feed enzymes to improve feed utilization by ruminants.** K. A. Beauchemin*[1], D. Colombatto[1], W. Z. Yang[1], and D. P. Morgavi[2], [1]*Agriculture and Agri-Food Canada, Research Centre, Lethbridge, Alberta, Canada* , [2]*INRA Centre Clermont-Theix, Saint-Genes-Champanelle, France.*

Research has demonstrated that supplementing dairy cow and feedlot cattle diets with fiber-degrading enzymes has significant potential to improve feed utilization and animal performance. Ruminant feed enzyme additives are concentrated fermentation products with specific enzyme activities, primarily xylanases and cellulases. Improvements in animal performance through enzyme supplementation can be attributed mainly to improvements in ruminal fiber digestion resulting in increased digestible energy intake. Animal responses are greatest when fiber digestion is compromised and when energy is the first limiting nutrient in the diet. When viewed across a variety of enzyme products and experimental conditions the response to feed enzymes by ruminants has been variable. This variation can be attributed to experimental conditions in which energy is not the limiting nutrient, as well as the activities and characteristics of the enzymes supplied, under or over-supplementation of enzyme activity, and inappropriate method of adding the enzyme to the diet. A limited number of ruminant enzyme products are now commercially available and this list of products is expected to grow. However, random use of enzymes on feeds, without consideration for specific situations and substrate targets, will only discourage or delay on-farm adoption of enzyme technology. Research is needed to understand the mode of action of feed enzymes so that efficacy can be assured. While much progress has been made in advancing enzyme technology for ruminants, considerable research is still required to reduce the variability of response. With increasing consumer concern about the use of growth promoters and antibiotics in livestock production, and the magnitude of increased animal performance obtainable using feed enzymes, there is no doubt that these products will play an increasingly important role in the future. This paper reviews the research on enzyme selection, the animal responses to feed enzymes and the mechanisms by which these products improve nutrient utilization.

**Key Words:** Feed Enzymes, Fiber Digestion, Nutrient Utilization

**415 Bacterial direct-fed microbials in ruminant diets: Performance response and mode of action.** C.R. Krehbiel* and S.E. Gilliland, *Oklahoma State University.*

Direct-fed microbials (DFM) have been shown to increase daily gain and feed efficiency in feedlot cattle, enhance milk production in dairy cows, and improve health and performance of young calves. However, effects of DFM on performance have been mixed, and the mode of action remains unclear. Bacteria used as DFM have been defined as mono or mixed cultures of live organisms that beneficially affect the host by improving the properties of the indigenous microflora. The original concept of feeding DFM to livestock was based on potential intestinal effects, including improved establishment of gut microflora and prevention of the establishment of pathogenic organisms. More recently, however, there has been some indication that certain bacterial DFM may have beneficial effects in the rumen, such as reducing the potential for ruminal acidosis. In 13 experiments, supplementing feedlot steers with lactate-utilizing and (or) lactate-producing bacteria has been shown to improve feed efficiency (range = -3.0 to 9.6%; avg = 3.3%) and daily

gain (range = -5.4 to 5.0%; avg = 2.2%) with little change in DMI. In addition, increased milk yield has been reported in studies in dairy cows fed DFM, with little change in milk composition. Few attempts have been made to determine the mechanisms responsible for the beneficial effects of DFM; attempts made have involved the potential for a reduction in subacute acidosis. Responses to bacterial DFM have included a reduction in area below subacute ruminal pH, increases in propionate and butyrate concentrations, increased protozoal numbers, and changes in viable bacterial counts. Some blood variables (lower $CO_2$ and LDH) also have indicated a reduced risk of metabolic acidosis. Recent research has shown reduced or inhibited fecal shedding of *Escherichia coli* O157:H7 from experimentally infected calves. Therefore, a possible application for DFM might be to reduce shedding of this pathogen from cattle. Overall, data indicate that DFM have the potential to reduce ruminal acidosis in feedlot cattle and dairy cows, and improve immune response in stressed calves. More research is needed to describe the mode of action, and thereby improve the efficiency of DFM use.

**Key Words:** Direct-fed microbials, Ruminant, Ruminal fermentation

**416 Effects of Tasco (a brown seaweed) and heat stress on immune function and antioxidant activity of wether lambs.** K.E. Saker*[1], J.H. Fike[1], H.P. Veit[1], and D.L. Ward[1], *Virginia Tech, Blacksburg, Virginia, USA*.

Effects of Tasco (a brown seaweed) and heat stress on immune function and antioxidant activity of wether lambs
K.E. Saker1, J.H. Fike2, H.P. Viet1, D.L. Ward1. 1VA-MD Regional College of Veterinary Medicine and 2 Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, VA
Twenty-seven wether lambs (initial avg BW 40 kg) were used to evaluate select innate immunity and oxidative stress in response to diet and heat stress. Endophyte-infested tall fescue-based pasture received 0 or 3 kg / ha of Tasco-Forage (an extract of the brown kelp Ascophyllum nodosum) prior to harvest and was compared to direct-feeding Tasco-EX. Lambs, blocked by weight, were randomly assigned to one of three diets. Diets were 1) control hay, 2) treated hay, and 3) diet 1 + Tasco-EX fed at an additional 1% of the as-fed diet. Heat stress was applied for 10 d following a 27-d diet adjustment period with measurements obtained at d 4 and 10. Tasco-EX application increased monocyte phagocytic activity (P=0.01) in lambs compared with pre-harvest (Tasco-Forage) and control diets. Heat stress influenced cell activity across all treatments (P<0.0001). Phagocytic cells from Tasco-EX treatment lambs exhibited increased (P<0.05) capacity for oxidative burst as compared to Tasco-Forage and control lambs. Phagocytes obtained from the Tasco-EX lambs maintained their capacity for oxidative burst throughout the heat stress period (P<0.01). Cell function decreased in response to heat in Control and Tasco-Forage lambs. A heat x diet interaction was apparent (P=0.10). Superoxide dismutase (SOD) and glutathione peroxidase (GPx) was consistently higher in leukocytes from Tasco-treatment lambs during heat stress periods. Minimal (P<0.001) cell peroxidation occurred due to Tasco-EX during heat stress. Tasco-Forage treatment of tall fescue hay appeared to provide residual effects on animal antioxidant availability in short-duration heat stress. Tasco-EX supplementation with tall fescue hay enhanced immune function and protected against prolonged heat-induced oxidative stress. Hay treatment with Tasco has the potential to provide substantial health benefits to ruminants in sub-optimal production scenarios.

**Key Words:** Seaweed, immunity, antioxidant

**417 Effects of a fibrolytic enzyme supplement on digestion and nutrient utilization by dairy cows fed alfalfa hay and grass silage-based rations.** S.E. Adams*[1], C.J. Sniffen[2], J.H. White[1], and J.R. Knapp[1], [1]*U. of Vermont,* [2]*W.H. Miner Institute*.

Two experiments were conducted to evaluate the effects of a fibrolytic enzyme supplement on dry matter (DM) intake, digestibility, microbial protein production, volatile fatty acid (VFA) and ammonia concentrations, and lactational performance. The supplement was a direct-fed mixture of cellulase, xylanase, and amylase enzymes. In experiment 1, nine multiparous lactating Holstein cows were blocked by parity and randomly assigned to diets. Diets were (DM basis) 50% concentrate and 20% corn silage with either 1) 30% alfalfa hay, 2) 15% alfalfa hay and 15% grass silage, or 3) 30% grass silage. Cows were offered the diet without enzyme supplementation for one collection period followed by a second period with enzyme supplementation. The enzyme increased DM intake for diets 1 and 3 and total tract apparent digestibility of starch and sugars for all three diets. Crude protein (CP) and sugar digestibilities were lower for diet 3 than diets 1 and 2. The enzyme did not affect milk yield or milk protein, but milk fat percent was lower with enzyme by 0.6% and with diet 1 by 0.3%. In experiment 2, four ruminally-fistulated, lactating Holstein cows were fed diets 1 and 3 with and without enzyme. Enzyme supplementation did not affect DM intake or lactational performance. Percent milk fat was 0.3% lower for diet 1. Total VFA and ammonia concentrations were higher for diet 3, but neither these nor the molar proportions of VFA were affected by enzyme supplementation. The enzyme did not affect rumen digestibility of DM, NDF, or ADF, but diet 3 degraded at a faster rate than diet 1. These results indicate that this enzyme supplement can increase the intake of digestible organic matter and the total tract digestibility of starch and sugars and that the digestion and utilization of nutrients in rations containing alfalfa hay and grass silage differ. More research is needed to determine why milk fat was decreased with enzyme supplementation in experiment 1.

**Key Words:** fibrolytic enzymes, fiber digestion, starch digestion

**418 Volatile fatty acid production rates of Holstein dairy cows provided monensin during the transition period.** X. Markantonatos[1], G. A. Varga*[1], T.W. Cassidy[1], R. K. McGuffey[2], R. Tucker[2], and L. F. Richardson[2], [1]*The Pennsylvania State University, PA,* [2]*Elanco Animal Health, IN*.

Eight multiparous Holstein rumen cannulated cows were used in a completely randomized design to evaluate the effects of monensin (**M**) inclusion during the transition period on ruminal VFA production rates. Treatments were a TMR topdressed with 300 mg M/d, or without M. Cows received M from d -30 prepartum (**Pre**) to d +56 postpartum (**Post**). All cows received the same diet consisting of 58:42 forage:concentrate (F:C) Pre or of 51:49 (F:C) Post. Isotopic tracers (1-13C3Na, 1-13C2Na, 1-13C4Na) at 12% enrichment were intraruminally infused using the single injection technique. Tracers were infused on d 13  d 1.97 prior to calving and on d 19  1.60 after parturition. Sampling times were -30, -20, -10, 5, 10,15, 25, 35, 45, 60, 75, 90, 110, 130, 150, 170, 210, 230, 260, 290, and 320 min relative to tracer infusion time. Three days prior to sampling, cows were fed every 4h for 2d followed by 2h feeding intervals 1d prior to and the day of sampling. Daily DMI, milk production, and weekly milk composition were measured. Blood metabolites for NEFA, BUN, and glucose were measured weekly. Pre acetate production rate was lower (P = 0.03) for cows provided M (1.24 mol/h vs. 1.62 mol/h  0.09), whereas propionate production rate was not affected by treatment. Production rate for butyrate was slightly lower for cows given M (P = 0.19) Pre. Supplementation of M did not alter VFA production rates Pre vs. Post. All VFA production rates were higher (P < 0.07) Post vs. Pre. No effects on Pre or Post DMI or blood metabolites were observed between treatments. Lower DMI (13. 5 kg/d Pre vs 19.4 kg/d Post; P< 0.01) resulted in significantly lower VFA production rates, (P< 0.01) and lower propionate endogenous pool (P <0.01) Pre vs Post. Supplementation of M did not affect milk yield or milk composition. This study suggests that M supplementation Pre may alter ruminal VFA production rates. However, DMI showed a greater overall effect on VFA production rates than M supplementation.

**Key Words:** Monensin, VFA Production Rates

**419 The influence of low concentrations of supplemental enzymes on ruminal fermentation and milk production in dairy cows.** J. Tricarico*[1], J. D. Johnston[2], and K. A. Dawson[1], [1]*Alltech Biotechnology Inc., Nicholasville, KY,* [2]*Ritchie Feed&Seed, Ottawa, Ontario, Canada*.

Twenty intact and four ruminally-fistulated lactating Holstein cows were used in a replicated 4x4 latin square design, to examine the effects of four concentrations of a supplemental enzyme preparation on milk production, milk composition, and ruminal digestibility and fermentation. The cows were allotted to one of six replicate squares based on days in milk and presence or absence of ruminal fistulas. The treatments included enzyme supplementation at 0, 6000, 12000 and 18000 units fungal alpha-amylase per cow per d. Treatment periods included a 14-d adaptation period prior to a 7-d collection period. Enzyme supplementation had a quadratic effect on milk production ($P$=0.02). The maximum milk yield was obtained with 6000 units fungal alpha-amylase per cow per d. Percent fat and protein in milk were not different in

the absence or presence of enzyme supplement and therefore resulted in greater ($P$<0.05) total fat and protein in milk. Enzyme supplementation had a significant cubic effect ($P$=0.03) on MUN. The addition of 6000 units fungal alpha-amylase per cow per d resulted in lower MUN than in any other treatment. Enzyme addition did not affect ruminal starch or NDF digestibility of corn silage but increased ($P$<0.01) the ruminal starch digestibility of grain corn by 7.8 % after *in situ* incubation for 24 h. The addition of 6000 units fungal alpha-amylase per cow per d did not affect total VFA concentrations in the rumen but reduced ($P$<0.01) propionate by 9.1 % and increased ($P$<0.01) acetate and butyrate proportions by 1.5 and 9.3 %, respectively. These results indicate that low concentrations of enzyme enhance performance in ruminant animals by modifiying fermentation in the rumen without having a significant impact in digestibility.

**Key Words:** Enzymes, Amylase, Dairy cows.

### 420 Predicting chewing and ruminal pH by measuring physically effective NDF of dairy cow diets.

W. Z. Yang* and K. A. Beauchemin, *Agriculture and Agri-Food Canada, Lethbridge, Canada*.

Recently, the concept of physically effective (pe) NDF was introduced to relate the physical characteristics of feeds to rumen pH. The peNDF content of the diet is determined by multiplying the NDF content of the diet by a pe factor. Several systems have been proposed for quantifying pe factors, including estimates based on chewing activity (peNDF$_M$) or particle length. The pe factors based on particle length can be estimated as the proportion of material retained on a 1.18 mm screen (peNDF$_{P>1.18}$) or as the sum of the material retained by the two sieves of the Penn State Particle Separator (peNDF$_{PS}$). The objectives of this study were to validate these systems and to establish the peNDF requirements for dairy cows. The study examined the peNDF content of a range of lactating dairy cow diets used in two studies in which chewing and rumen pH variables were assessed. The peNDF$_{PS}$ content of the diets was about 40 to 60% lower ($P < 0.01$) than the peNDF$_M$ and peNDF$_{P>1.18}$ contents, which were similar. Eating time was generally not affected by the peNDF content of the diet, but ruminating time was increased ($P < 0.05$) with increased peNDF content. The peNDF$_M$ and peNDF$_{P>1.18}$ were correlated (r=0.55, $P < 0.03$) to total chewing activity when the values ranged from 18 to 24%, but no correlation was observed beyond that range of peNDF. Increased peNDF content of the diets increased ($P < 0.05$) mean rumen pH and improved ($P < 0.01$) ruminal pH status: time during which ruminal pH was below 5.8 decreased when the peNDF$_M$ and peNDF$_{P>1.18}$ content increased from 18 to 24%. These results suggest that the peNDF content of the diet is a reliable indicator of chewing activity and rumen pH, particularly with diets low in fiber. However, there can be substantial variation in the estimates of peNDF content of diets depending upon the method used to determine the pe factor.

**Key Words:** Physically Effective NDF, Chewing Behavior, Ruminal pH, Dairy Cows

### 421 Is fibrosity better evaluated by dietary mean particle size or percentage of dry matter retained by a 2-mm sieve ?.

D. Sauvant*[1] and D. Mertens[2], [1]*Institut National Agronomique Paris-Grignon - INRA,* [2]*US Dairy Forage Research Center.*

Mean particle size (MPS) includes the impact of small particles on particle size distribution ; whereas the percentage retained on a sieve with 2-mm apertures (P > 2mm) includes only the effects of larger particles. A database was compiled from 20 publications that included 42 experiments (nexp) and 99 treatments (n) in which indicators of fibrosity and feed particle size were measured. All treatments reported measures of MPS (mean sd: 3.1 1.2 mm, range = .8 to 8.0 mm) and P > 2mm (40.7 16.3 %, range = 4.4 to 85 %). The GLM procedure was used in a meta analysis to evaluate relationships across experiments (global) or to partition within and among experiment variation (EXP included in the model). Both the linear and quadratic functions of P > 2 mm and MPS were tested. Although they were related globally (P > 2mm = 7.44 MPS + 18.2, R2 = .30, rsd = 13.7 %), the low R2 suggested that P > 2 mm and MPS were different measures of particle size. Each was compared to indicators of dietary fibrosity : mastication time per day (MAST = 661 152 min/d, n = 93, nexp = 39) or per kg of dry matter intake (IM = 34.3 18.6 min/kg DMI, n = 93, nexp = 39), rumen pH (pH = 6.14 0.31, n = 42, nexp = 18), acetate/propionate ratio (A/P = 2.70 0.60, n = 67, nexp = 27), milk fat content (MFC = 3.49 0.65 %, n = 94, nexp = 40). Except for P > 2mm in fitting A/P, all the models included linear and quadratic influences of MPS and P > 2mm. The R2 and residual standard deviations were: .89 vs .90 and 68.1 vs 64.1 for MAST ; .98 vs .98 and 3.1 vs 3.0 for IM; .86 vs .91 and 0.16 vs 0.13 for Ph ; .84 and .85 and 0.32 vs 0.30 for A/P; and .93 vs .91 and 0.22 vs 0.21 % for MFC ; for MPS vs P > 2 mm, respectively. Differencies were small but favored P > 2 mm as an indicator of fibrosity. When dietary NDF was included in the model, the ranking between P > 2 mm and MPS remained similar for all variables. In conclusion, P > 2 mm is easier to assess than MPS and provided slightly more accurate relationships with indicators of diet fibrosity.

**Key Words:** effective fiber, chewing, particle size

### 422 Interaction of corn silage processing and replacement of concentrate with nonforage sources of fiber on performance and digestion characteristics of lactating dairy cows.

J. A. Mills* and R. J. Grant, *University of Nebraska*.

Effects of corn silage crop-processing and replacement of concentrate with nonforage sources of fiber [wet corn gluten feed (WCGF), soybean hulls (SH)] on intake, carbohydrate digestion, and milk production were evaluated. Corn silage was harvested at 38% whole-plant moisture and approximately 1.2 cm TLC without processing, or approximately 1.9 cm TLC with processing, at a 2-mm roll clearance. Eighteen Holstein cows (12 primiparous) averaging 86 DIM were fed in a replicated 6 × 6 Latin square with 21-d period. Two control diets contained 40% of either unprocessed or processed corn silage, 10% alfalfa silage, and 50% concentrate mixture (DM basis; 29% dietary NDF). The concentrate mixture of the two control diets was replaced with 30% WCGF, or 20% SH to make up the remaining four diets (38 and 39% dietary NDF, respectively). There were few significant interactions between corn silage processing and use of nonforage fiber sources. Corn silage processing had no significant effect on DMI, NDF intake, milk yield, milk fat, 4% FCM, and FCM efficiency. Dry matter intake was greatest ($P < 0.001$) when cows were fed diets containing WCGF. Milk yield tended to be greater ($P < 0.14$) for diets containing either WCGF or SH compared with control. However, diets containing WCGF had significantly greater ($P < 0.05$) milk yield than SH treatments (37.7 vs. 36.4 kg/d, respectively). Milk protein percentage and lactose yield increased ($P < 0.05$) with corn silage processing. There were no effects of treatment on ruminal pH (average 6.08), but acetate to propionate ratio was highest for SH diet. Processing had no effect on total tract DM, NDF, or starch digestibility. However, DM, NDF, and starch digestion were significantly higher ($P < 0.05$) when WCGF or SH replaced concentrate. Corn silage processing had little effect on lactational performance; however, replacement of concentrate with WCGF and SH significantly improved dairy cattle performance and carbohydrate digestion.

**Key Words:** Corn silage processing, Wet corn gluten feed, Soybean hulls

### 423 Meta-analysis of relationships between particle outflow rate and mastication in cattle.

D. Sauvant*[1] and D. Mertens[2], [1]*Institut National Agronomique Paris-Grignon - INRA,* [2]*US Dairy Forage Research Center.*

A database of 26 publications, 43 experiments (nexp) and 106 treatments (n) was compiled to explore the relationships between the hourly outflow rate of particles (kp = 4.7 1.7 %/h, range = 0.9 to 8.9) and daily mastication (MAST = 12.47 2.96 h/d, range = 3.15 to 17.80). Other measured variables were dietary NDF (NDF = 38.4 12.8%DM) and dry matter intake as a percentage of live weight (DMI = 3.0 0.7 %). A meta analysis partitioned variation into mean responses of kp, MAST, DMI, NDF among the experiments and residuals from the mean response within experiments. The relationship among experiments between kp and MAST was negative (kp = 7.7 ± 0.26 MAST, n = 43, R2 = 19.4 %, rsd = 1.5), as was the relationship between DMI and NDF (DMI = 4.92 ± 0.50 NDF, n = 43, R2 = 80.6 %, rsd = 0.3). Among experiments, dietary NDF influenced both kp (kp = 6.67 ± 0.056 NDF, n = 43, R2 = 17.2 %, rsd = 1.5) and MAST (MAST = 6.85 + 0.148 NDF, n = 43, R2 = 40.9 %, rsd = 2.2). The influences of DMI were the opposite of NDF for kp (kp = 1.44 + 1.02 DMI, n = 43, R2 = 17.4 %, rsd = 1.5) and MAST (MAST = 19.2 ± 2.21 DMI, n = 43, R2 = 28.2 %, rsd = 2.4). The within experiment relationship was positive between the residuals of kp (reskp, sd = 0.47) and MAST (resMAST, sd = 0.98):

reskp = 0.12 resMAST, n = 106, rsd = 0.4. The within experiment influences of dietary NDF residuals (resNDF, sd = 3.0 ) was negative for kp (reskp = - 0.059 resNDF, rsd = 0.4) and positive for MAST (resMAST = 0.088 resNDF, rsd = 0.9). For DMI the corresponding relationships were: reskp = 1.03 resDMI, rsd = 0.4; resMAST = 0.73 resDMI, rsd = 1.0. The influences of DMI and NDF remained similar among and within experiments for kp but not for MAST. When DMI decreased as dietary fill (as indicated by NDF and MAST) increased among experiments there was a mean decrease of kp of 0.26 %/h per hour of increase of MAST. In contrast, within the same experiments there was an increase of kp of 0.12 %/h per hour of increase of MAST.

**Key Words:** particle outflow rate, mastication

## Ruminant Nutrition
## Minerals

**424 Effect of trace mineral source on performance of dairy cattle: lactation and reproduction responses.** H. T. Ballantine*[1], M. T. Socha[2], D. J. Tomlinson[2], A. B. Johnson[2], A. S. Fielding[3], J. K. Shearer[4], S van Amstel[5], and C. J. Rapp[2], [1]*Ballantine Consulting,* [2]*Zinpro Corporation,* [3]*Purina Mills, LLC,* [4]*University of Florida,* [5]*University of Tennessee.*

Three hundred multiparous Holstein cows (150 cows/treatment) were blocked according to calving date and randomly assigned to a study to determine effect of trace mineral source on performance. Treatments were 1) all trace minerals supplied by sulfates or 2) 360 mg of zinc, 200 mg of manganese, 125 mg of copper and 12 mg of cobalt per day of sulfate trace minerals replaced with complexed sources (Availa®, Zinpro Corporation). Cows received their respective treatments from 21 d prior to calving through 250 d of lactation. Lactation diets were formulated to provide (DM basis) 155 mg/kg zinc, 119 mg/kg manganese, 23 mg/kg copper and 1.5 mg/kg cobalt. Cows were milked 3X/d and milk yield recorded. Liver biopsies were collected from cows (30 cows/treatment) prior to treatment assignment and at approximately 14 weeks postcalving. Feeding complexed trace minerals increased yields of milk (41.8 vs. 40.6 kg/d), energy-corrected milk (40.5 vs. 39.3 kg/d) and 3.5% fat-corrected milk (40.7 vs. 39.5 kg/d) and increased yields of milk fat and protein by 0.04 kg/d. There was no effect of treatment on milk composition or somatic cell counts. Replacing sulfate trace minerals with complexed trace minerals decreased days open by 22 days (169 vs. 147 d) and tended to increase % of cows pregnant by 150 DIM (54.8 vs. 42.7%) and first service conception rates (27.4 vs. 18.4%). Despite differences in performance between cows fed different sources of trace minerals, there was no effect of treatment on zinc, manganese and copper content of liver. Replacing zinc, manganese, copper and cobalt from sulfates with complexed sources improved lactation and reproductive performance of dairy cattle.

**Key Words:** Complexed Trace Minerals, Dairy Cattle, Reproduction

**425 Effect of trace mineral source on performance of dairy cattle: claw integrity.** H. T. Ballantine[1], C. J. Rapp*[2], M. T. Socha[2], D. J. Tomlinson[2], A. B. Johnson[2], A. S. Fielding[3], J. K. Shearer[4], and S. van Amstel[5], [1]*Ballantine Consulting,* [2]*Zinpro Corporation,* [3]*Purina Mills LLC,* [4]*University of Florida,* [5]*University of Tennessee.*

Three hundred multiparous Holstein cows (150 cows/treatment) were blocked according to calving date and randomly assigned to a study to determine effect of trace mineral source on performance. Treatments were 1) all trace minerals supplied by sulfates or 2) 360 mg of zinc, 200 mg of manganese, 125 mg of copper and 12 mg of cobalt per day of sulfate trace minerals replaced with complexed sources (Availa®, Zinpro Corporation). Cows received their respective treatments from 21 d prior to calving through 250 d of lactation. Lactation diets were formulated to provide (DM basis) 155 mg/kg zinc, 119 mg/kg manganese, 23 mg/kg copper and 1.5 mg/kg cobalt. Claws were examined prior to initiation of treatments and at 75 and 250 d postcalving. Claw evaluators were graduates of the Master Hoof Care Program and were not informed of cow treatment assignment. Lesions were noted in the seven zones of the claw and scored for degree of pain (1 = no pain, 3 = severe pain). For cows exhibiting a noted claw disorder, a claw lesion index was calculated by multiplying the average pain score of the lesions by the number of zones affected. Data collected prior to treatment assignment was used to covariately adjustment data collected at 75 and 250 d postpartum. Replacing sulfate trace minerals with complexed trace minerals tended to reduce incidence of claw disorders at 75 d postpartum (23.6 vs. 34.1%) and incidence of white line disease at 75 (9.5 vs. 14.6%) and 250 d postpartum (4.9 vs. 8.8%). Complexed trace minerals reduced claw lesion indexes (indicator of lesion severity) for white line disease at 75 d postpartum (1.3 vs. 2.6) and tended to reduce claw lesion indexes for heel erosion at 75 d postpartum (6.7 vs. 8.9), white line disease at 250 d postpartum (1.7 vs. 2.7), and sole ulcers at 250 d postpartum (2.5 vs. 4.2). Replacing zinc, manganese, copper and cobalt from sulfates with complexed sources improved claw integrity of lactating dairy cattle.

**Key Words:** Complexed Trace Minerals, Dairy Cattle, Claws

**426 Summary of twelve trials evaluating the effect of feeding complexed zinc methionine on lactation performance of dairy cattle.** D. J. Tomlinson*, M. T. Socha, C. J. Rapp, and A. B. Johnson, *Zinpro Corporation, Eden Prairie, MN.*

The objective of this review was to summarize twelve trials (13 comparisons) evaluating the effect of feeding complexed zinc methionine (ZINPRO®, Zinpro Corporation, Eden Prairie, Minnesota) on lactation performance and udder health, as measured by somatic cell count, of dairy cattle. Summarized trials were conducted at Washington State (2), Colorado State (2), Cornell, Illinois State, Arkansas, Missouri, Georgia, Great Britian, Germany and Israel. In five of the trials, ZINPRO provided between 180 and 200 mg of zinc per head per day. In the remaining seven trials (eight comparisons) ZINPRO supplied 360 to 400 mg of zinc. In all diets, cows received additional zinc from inorganic sources. The control diet in one of the Missouri comparisons, the Germany study, the Cornell study and one of the Colorado State studies did not meet NRC (2001) recommendations for zinc (43 ppm, calculated for a lactating Holstein dairy cow: 42 months of age, $2^{nd}$lactation, 658 kg BW, 110 DIM, 31.7 kg milk at 3.48% fat, 2.91% true protein and 22.6 kg DMI). Both control and treatment diets fed in the Illinois State study were below NRC (2001) zinc recommendations. All other diets met or exceeded NRC (2001) zinc recommendations. Each trial was a block with each treatment lsmean within a trial treated as an observation. Cows fed the complexed zinc produced more ($P<0.01$) milk (31.8 vs. 30.5 kg/d), energy-corrected milk (31.7 vs. 30.4 kg/d) and fat-corrected milk (31.6 vs. 30.0 kg/d). Milk composition did not differ between treatment and control cows, although cows receiving complexed zinc produced more ($P<0.05$) milk fat (1.10 vs. 1.06 kg/d) and more ($P<0.01$) milk protein (0.99 vs. 0.96 kg/d). Somatic cell count (1,000s/ml) was reduced from 294 to 196 ($P<0.01$). This summary of twelve dairy trials indicates that feeding complexed zinc methionine increases lactation performance and improves udder health as evidenced by a 33.3% reduction in somatic cell count.

**Key Words:** Trace Minerals, Dairy Cattle, Somatic Cell Count

**427 Effect of chelated trace mineral supplementation for inorganic sources on production and health of Holstein cows.** J.E. Nocek[1] and R.S. Patton[2], [1]*Auburn, NY,* [2]*Galisteo, NM.*

Multiparous Holstein cows were used to evaluate the effect of chelated trace minerals (Keylated Proteinated Minerals, Chelated Minerals Corp., Salt Lake City, UT) on production performance. Prior to dry off, cows were balanced by parity, 305ME and assigned to control (n=324) or treatment (n=318) from -60 to 150 days in milk (DIM). Culling resulted in 261 cows per group at trial end. Control cows received Zn, Cu and Mn added to the total mixed ration (TMR) at 120% of NRC as inorganics. Treatment cows received the same total supplementation as 50% inorganics and 50% chelates. Diets were corn and grass silage based during the dry period and corn silage and alfalfa silage based during transition and lactation. Data on milk production, reporduction, disease and hoof health was collected to 150 DIM. Cows supplemented with chelates produced more ($P = .02$) milk than controls (38.6 vs 38.3 kg/d). Milk protein, fat and SCC were not different. Chelate supplemented cows