560 Meta analysis of dairy cow responses to dietary forage NDF. D. Sauvant*[1] and D. R. Mertens[2], [1]*Agroparistech-INRA*, *Paris, France*, [2]*US Dairy Forage Center*, *Madison, WI.*

Dietary forage NDF (fNDF) offers the potential of combining fiber and its particle size influences in a common index. For this reason, it may be more precise than dietary NDF or proportion of concentrate to predict dairy cow responses. To evaluate this hypothesis a database was compiled from 116 published experiments (n = 289 treatments) where dietary NDF or concentrate varied. Forages were long or coarsely chopped. Dietary NDF averaged 34.4 ± 8.2% of DM while fNDF was 26.2 ± 10.2% (from 11.0 to 59.6). Meta analyses with GLM allowed to focuse on within experiment regressions. Chewing index (CI; 38.2 ± 11.8 min chewing/kg DM Intake) was linearly related to fNDF (CI = 19.8 + 0.70 fNDF, n = 195, nexp = 80, rmse = 2.9). Mastication time also increased with fNDF, but obtained a plateau of 865 min/d at fNDF around 52%. Dry matter intake (20.4 ± 3.5 kg/d) was related negatively and curvilinearly to fNDF (= 22.6 - 0.003 fNDF2, rmse = 1.1), and milk yield (28.3 ± 7.1 kg/d) presented a similar shape (= 22.6 - 0.005 fNDF2, rmse = 1.4). Opposite responses were observed for milk percentages of fat (= 2.5 + 0.07 fNDF - 0.00008 fNDF2, rmse = 0.17) and protein (= 3.3 + 0.001 fNDF - 0.00001 fNDF2, rmse = 0.08). Ruminal pH was positively related to fNDF (= 5.62 + 0.023 fNDF - 0.00014 fNDF2, n = 145, nexp = 56, rmse = 0.08). Acetate/propionate ratio increased with fNDF (= 1.05 + 0.10 fNDF - 0.001 fNDF2, n = 163, nexp = 66, rmse = 0.24). Values of pH = 6.1 and A/*P* = 3.0 corresponded to fNDF = 24%. An increase in fNDF significantly increased the rumen liquid load (RLL = 73 ± 11.1 kg, = 53.6 + 1.14 fNDF - 0.014 fNDF2, n = 76, nexp = 32, rmse = 5.0) and rumen liquid outflow rate. In contrast, fNDF decreased the organic matter digestibility (= 74.1 - 0.139 fNDF, n = 186, nexp = 73, rmse = 2.3) and the energy balance became negative when fNDF > 31.5%. In conclusion, most predictions were curvilinear and fairly accurate. As a measure of fill effect, the minimization of fNDF enhances the milk performance, however when fNDF is < 20–25% DM the risk of acidosis increases.

Key Words: forage NDF, dairy cow, meta analysis

561 Effect of forage type on passage rate estimated from rumen evacuation studies. S. J. Krizsan*[1], S. Ahvenjärvi[2], and P. Huhtanen[1], [1]*Department of Agricultural Research for Northern Sweden, Swedish University of Agricultural Sciences*, *Umeå, Sweden*, [2]*MTT-Agrifood Research Finland, Animal Production Research*, *Jokioinen, Finland*.

A meta-analysis of studies using the flux/compartmental pool method with indigestible NDF (iNDF) as internal marker was conducted to study the effect of forage type on particle passage rate (k_p) in cattle. Data were comprised of 172 treatment means from 49 studies conducted in Europe and in the USA. A total of 145 diets were fed to dairy cows and 27 to growing cattle. Prerequisite for inclusion of an experiment was that DMI, intake of NDF (NDFI), proportion of concentrate (CProp) in the diets, live weight (LW), and diet chemical composition (concentrations of CP, NDF, NFC and iNDF) were determined or could be estimated. Mixed model regression analysis including a random study effect was used to generate prediction equations of k_p. Initially 13 different forage types were classified, but when not different ($P > 0.10$) from grass silage the groups were pooled. The best fit model when forage type was not included was: k_p (%) = 1.19 + 0.0879 × NDFI (g/kg LW) + 0.792 × CProp (on NDF basis) + 1.21 × iNDF/NDF (RMSE = 0.231%, Akaike's information criterion = 199 and $R^2 = 0.66$). The best general equation correcting for the effect of forage type was: k_p (%) = 1.54 + 0.0866 × NDFI (g/kg LW) (RMSE = 0.207% and $R^2 = 0.80$). The effect on k_p of fresh grass (FG), mixes of alfalfa and corn silage(AS/CS) and dry or ensiled alfalfa as sole forage component (AH/AS) were estimated by adjusting the intercept in the general equation accounting for forage. The adjustment factor on the intercept for FG, AS/CS and AH/AS were −0.914, +0.831 and +0.237, respectively. The results from this meta-analysis suggested that consistency of ruminal digesta is affected by intrinsic forage characteristics that influence particle passage rate. Further, including an effect of forage type on k_p could not be explained by any of the chemical composition parameters of the diets.

Key Words: cattle, forage type, passage rate

562 Abrupt changes in forage dry matter of one to three days affect intake and milk yield in early lactation dairy cows. J. Boyd* and D. R. Mertens, *US Dairy Forage Research Center*, *Madison, WI.*

Our objective was to determine the effects of 1, 2, and 3 d changes in forage dry matter on lactating cow performance and yield. Forty-four Holstein cows (22 primiparous and 22 multiparous) averaging 65 DIM, 43.3 kg/d of milk, and 574 kg body weight were used in study conducted from October through December 2009. Within each parity, cows were assigned to 1 of 11 blocks based on production and days in lactation and one cow of each parity-block was randomly assigned to 1 of 2 groups. Study design was replicated 2 × 2 Latin squares for each set 1, 2, or 3 d treatments. Each period consisted of a 3d pre-treatment, 1 to 3d treatment, and a 3d post-treatment phase. Diets contained about 18% alfalfa and 36% corn silage (DM basis) and were control (Ctrl) with no water added and treatment (Trt) with water added to decrease forage DM by 8%-units, which mimicked rainfall events on a bunker silo and feeding an imprecise ration based on as-fed ratios of ingredients. Ctrl ration was adjusted daily to maintain DM ratios of ingredients during the study. Milk yield was recorded daily and component samples were taken 2x daily. Forages, TMR, and refusals were sampled daily and concentrates sampled 2x weekly. Chemical composition (DM, CP, NDF) of samples were determined by NIR. Data was analyzed using Proc MIXED of SAS with cow within parity-block as a random variable. On day1, DMI was reduced 2.4 ($P < 0.0001$), 1.2 ($P = 0.0001$), and 0.8 kg ($P = 0.003$), for the 1, 2, and 3d treatments, respectively, but DMI recovered during the following 1 to 3 d even during Trt phases. Although daily milk decreased slightly on day1 of each Trt, the decrease was largest on day2: −1.4 ($P = 0.02$), −2.6 ($P = 0.002$) and −1.9 kg ($P = 0.006$), for the 1, 2, and 3d treatments, respectively. Smaller reductions in daily milk occurred on the remaining days of Trt and for 4% fat-corrected milk. We conclude that abrupt changes in forage DM cause economically significant reductions in daily milk yield, but the duration of the change does not worsen the losses if adequate ration amounts are provided.

Key Words: dry matter changes, precision feeding, milk yield

563 Effects of corn silage harvested with or without ears on rumen fermentation and milk performance of dairy cows. M. Boivin*, R. Gervais, and P. Y. Chouinard, *Université Laval*, *Québec, QC, Canada*.

The objective of this study was to evaluate the effects of grain fraction in corn silage (CS) on rumen fermentation and milk performance of dairy cows. To reach this objective corn ears were manually removed from half of the plants in the same field. Whole CS and earless CS were

harvested the day after. Eight multiparous (4 rumen fistulated) Holstein cows (84 ± 31 DIM) were fed TMR in a double 4x4 Latin square design with 21-d periods. Treatments were WCS: 23% whole CS (DM basis), RCS: reconstituted CS with 12.4% earless CS and 10.6% high moisture corn, ECS: 23% earless CS, and GS: 23% grass silage. All TMR contained alfalfa silage, grass hay, ground corn, soybean meal, corn gluten meal, soy hulls, and corn oil. Contrasts were made to compare WCS vs. RCS, WCS vs. ECS, and ECS vs. GS. Statistical difference was declared at $P < 0.05$, and tendency at $0.05 \leq P \leq 0.10$. DMI did not differ between WCS and RCS or between ECS and GS, but was higher for WCS compared with ECS (27.5 vs. 25.2 kg/d). Milk yield was higher with WCS than ECS and RCS (42.8, 39.0 and 39.5 kg/d, respectively), and tended to be higher with GS (40.7 kg/d) than ECS. Milk fat content and yield were unaffected by treatments. Milk protein content of ECS was lower than WCS (2.94 vs. 3.04%) and tended to be lower than GS (2.99%). Milk protein contents of WCS and RCS were similar. Milk protein yield was higher for WCS than RCS and ECS, and was lower for ECS than GS (1.30, 1.20, 1.14, 1.21 kg/d, respectively). Rumen pH recorded at 0, 1, 2, 4 and 6 h post feeding decreased linearly with time, but was not affected by treatments. Mean rumen NH3-N concentrations recorded at the same sampling times were lower with GS than ECS (10.8 vs. 12.6 mg/dl). Mean proportions of acetate were lower and those of propionate were higher for WCS than for ECS (59.9 vs. 61.9% and 22.1 vs. 19.8%, respectively). Acetate to propionate ratio was greater with ECS compared with WCS (3.14 vs. 2.74). Under the condition of this experiment removing the grain fraction from CS reduced milk production and modified ruminal fermentation without affecting milk fat content and yield.

Key Words: corn silage, corn stalklage, forage-to-concentrate ratio

564 Comparison of alfalfa and orchardgrass hay as replacements for grain in lactating dairy cow diets. M. L. Raeth-Knight*[1], H. G. Jung[1,2], P. R. Peterson[1], N. B. Litherland[1], and J. G. Linn[1], [1]*University of Minnesota*, *St. Paul*, [2]*USDA-Agricultural Research Service*, *St. Paul, MN*.

A study was conducted to compare lactating dairy cow performance when alfalfa (40% NDF) or orchardgrass (60% NDF) hay replaced corn grain in a corn silage-based total mixed ration. Fifty cows were blocked by sire breed, ranked by DIM and randomly assigned to 1 of 10 treatments. Treatments were 5 dietary inclusion levels of either alfalfa (15, 20, 25, 30 and 35% of diet DM) or orchardgrass (10, 15, 20, 25 and 30% of diet DM). Across treatments, cows averaged 86 DIM at study initiation, and cows remained on their respective treatments for 8 wk. Feed intake, feed refusals, and milk production were recorded daily, and milk composition was determined weekly. During wk 4 and 8, fecal grab samples were collected to determine in vivo diet digestibility; and eating, ruminating and resting time were recorded every 15 min for 24 h. Within alfalfa and orchardgrass treatments, 3.5% FCM yield decreased with increasing hay inclusion level (r2 = 0.59). The rate of decline was similar between hay species with cows averaging 44.6 and 37.3 kg 3.5% FCM/d at the lowest and highest hay inclusion levels, respectively, across hay species. When milk production was regressed on diet NDF concentration, within hay species, 3.5% FCM yield declined at a faster rate for the alfalfa as dietary NDF concentration increased. Range in diet NDF was 29.5 to 35.6% NDF and 29.9 to 39.8% NDF for alfalfa and orchardgrass, respectively. With each percentage unit increase in dietary NDF concentration, 3.5% FCM yield decreased 1.22 kg/d and 0.46 kg/d for alfalfa and orchardgrass, respectively. There was no difference in milk fat (3.8%) or true protein (3.0%) among treatments. Rate of in vitro NDF digestibility (IVNDFD) was similar (4.6 vs. 5.2%/h), while extent of IVNDFD was greater (79% vs. 56%) for orchardgrass compared with alfalfa hay. In this study, these alfalfa and orchardgrass hays supported similar levels of milk production when they replaced corn grain in the diet.

Key Words: dairy nutrition, alfalfa, orchardgrass

565 The effect of feed sorting on NDF, starch, and particle intake. D. D. Maulfair*, G. I. Zanton, and A. J. Heinrichs, *The Pennsylvania State University*, *University Park*.

Ration sorting occurs when cattle selectively consume certain parts of their ration, generally sorting for finer particles and against longer particles. Sorting is thought to have negative impacts on cow health and production. The objective of this experiment was to study the effects of varying TMR particle size on sorting behavior of lactating dairy cows and to evaluate effects on chewing behavior, milk yield and components, and rumen fermentation. Eight multiparous, Holstein cows (90 ± 32 d in milk; 4 rumen cannulated) were randomly assigned to replicated 4 × 4 Latin squares. Cows were fed diets that varied in chop length of dry grass hay. Diet forages and their percentage of diet DM were: corn silage (29.4), haylage (17.6), and grass hay (11.8). The geometric mean lengths (X_{gm}) of diets fed were: 4.46, 5.10, 5.32, and 5.84 mm for the short (S), medium (M), long (L), and extra long (XL) TMR respectively. Consumed X_{gm} for diets after 24 h was 4.44, 4.90, 4.82, and 5.10 mm for the S, M, L, and XL diets respectively. Differences between X_{gm} at time of feeding and after 24 h increased with increasing TMR particle size. In addition, refusal NDF concentration increased by 10.8 and 1.4%, while refusal starch concentrations decreased by 6.4% and increased by 1.5% throughout the day for the longest and shortest diets respectively. However, when NDF and starch intake were calculated after 24 h, mean NDF intakes varied by only 2.3 kg and there were no differences in starch intake. No differences were found in rumen VFA and NH_3 and mean rumen pH only varied by 0.13. Milk production and components were also similar between diets. Despite large changes in particle size distribution and NDF and starch concentrations of refusals due to sorting, there were no negative effects on rumen fermentation or milk production and components found in this study. Therefore, it is important to calculate the actual consumption of diet components to determine if sorting is a problem, because diet refusals represent only a small percentage of total diet intakes.

Key Words: chewing, particle size, sorting

566 Effects of varying inclusion rates of prairie hay and wet corn gluten feed on productivity of dairy cows. D. J. Rezac*[1], K. N. Grigsby[2], and B. J. Bradford[1], [1]*Kansas State University*, *Manhattan,*[2]*Cargill Incorporated*, *Blair, NE*.

Productivity of lactating dairy cows fed diets with wet corn gluten feed (Sweet Bran, Cargill Inc.; WGCF) as the primary energy substrate and prairie hay as the primary source of physically effective NDF (peNDF) was assessed versus a control diet. Forty-eight Holstein cows, 100–250 d in milk, were randomly assigned to 1 of 6 pens and pens were randomly assigned to treatment sequence in a replicated 3x3 Latin square. Treatments were a control ration with 18% alfalfa, 18% corn silage, 33% WCGF, and 15% forage NDF (CON); a diet with 20% prairie hay, 46% WCGF, and 13% forage NDF (PH20); and a diet with 14% prairie hay, 56% WCGF, and 9% forage NDF (PH14). However, midway through period 2, PH14 was discontinued due to numerous cases of diarrhea among cows on that treatment. Data from period 2 for PH14 pens was discarded and the pens which had been assigned to PH14 for period 3 were randomly assigned to the other treatments. Data were analyzed

with mixed models using random effects of period and pen and fixed effect of treatment. Dry matter intake was not altered by treatment. Least squares means milk yields were 36.2, 34.6, and 35.6 kg/d for CON, PH20 and PH14, respectively; milk yield was significantly greater for CON than PH20 ($P = 0.03$). Milk fat concentration was lowest for PH14 ($P < 0.01$), with means of 3.47, 3.40, and 2.82% for CON, PH20, and PH14, respectively. Fat yield was significantly greater for CON compared with PH14 ($P < 0.01$) but was not different from PH20. Milk urea nitrogen was the greatest for PH20 and least for CON ($P < 0.01$) with PH14 being intermediate, consistent with differences in dietary protein. Efficiencies, expressed as energy corrected milk divided by DMI, were 1.45, 1.40, and1.30 for CON, PH20, and PH14, respectively, and were not significantly different. These data suggest that PH14 did not provide adequate peNDF to support normal rumen function in midlactation dairy cows; however, PH20 offered a feasible diet for use on dairies where high-NDF grass hay and WCGF are available.

Key Words: non-forage fiber, physically effective fiber, wet corn gluten feed

567 Fiber digestion kinetics in muskoxen. E. M. Ungerfeld*[2], R. J. Forster[2], P. B. Barboza[1], M. B. Leigh[1], and C. Glover[1], [1]*University of Alaska Fairbanks*, *Fairbanks,* [2]*Agriculture and Agri-Food Canada*, *Lethbridge, Alberta, Canada*.

The objective of this study was to examine fiber digestion in the muskox rumen as a potential source of enzymes and microbes for biofuel production from fibrous biomass. We measured the kinetics of ruminal digestion in situ for triticale straw (low quality diet) and brome hay (medium quality diet) in a 2-period crossover design (n = 4). Each period consisted of 3 weeks adaptation to diets, after which pairs of polyester bags containing triticale straw or brome hay ground through 1mm mesh were placed in the rumen for 24 to 120 h. Negative exponential regressions were fitted to calculate fractional rate and extent of digestion of cellulose (defined as ADF – lignin), hemicellulose (NDF – ADF) and lignin for each animal-diet-substrate combination. Responses were initially modeled as functions of animal (random), period (random), diet, substrate, animal × substrate (random), period × substrate (random) and diet × substrate. Interactions were not significant for any response variable and were dropped from models. Cellulose digestion rate of both substrates was greater ($P = 0.004$) in animals fed straw than in those fed hay, indicating dietary induction of cellulotyic activity. Cellulose digestion rate was similar between substrates ($P = 0.69$) even though more cellulose was digested from hay than from straw ($P < 0.001$). Diet did not affect the rate ($P = 0.86$) or extent ($P = 0.24$) of hemicellulose digestion from either substrate. Hemicellulose digestion rate was greater ($P = 0.033$) in straw than in hay substrate, but its extent of digestion was greater ($P = 0.001$) in hay. Small values for lignin digestion at 120 h were greater for hay as substrate ($P < 0.001$) and for straw as a diet ($P = 0.012$). Results suggest that, for the substrate processing used, cellulose digestion rate, but not extent, was limited by microbial enzymatic activity, whereas hemicellulose digestion rate and extent was limited by surface available for microbial colonization and digestion. Muskoxen consuming low quality forages may induce cellulolysis and could be a potential source of useful fibrolytic microbes and enzymes.

Key Words: muskox, rumen, digestion

568 Nutrient utilization of different levels of dietary fiber in dairy heifers limit-fed high and low concentrate diets. G. J. Lascano* and A. J. Heinrichs, *The Pennsylvania State University*, *University Park*.

The objective of this experiment was to assess the optimal levels of dietary fiber (DF) incorporated in high concentrate (HC) and low concentrate (LC) diets for limit-fed dairy heifers. Eight Holstein heifers (335.6 ± 7.41 kg BW) were randomly assigned to 2 levels of concentrate: HC (20% forage) and LC (80% forage) and to a forage type sequence (0% of forage as corn stover (CT), 100% corn silage (CS); 20% CT, 80% CS; 40% CT, 60% CS; 60% CT, 40% CS) within forage level administered according to a split-plot, 4 × 4 Latin square design (21-d periods). All diets provided similar intakes of ME and allowed 800 g/d of ADG. DF (NDF and ADF) and non fiber carbohydrates composition were allowed to vary with the dietary ingredients. HC-fed heifers had higher apparent total tract (TD) digestibility of dry matter (DM; 72.6 vs.64.9 ± 0.52%; $P \leq 0.01$) than LC. Increasing DF level by increasing the amount of CT in the diet resulted in a linear decrease of DMTD (73.3, 71.5, 66.2 and 63.9 ± 0.51%, respectively; $P \leq 0.01$). Organic matter TD followed the same pattern as DMTD. LC diets had higher NDF ($P \leq 0.01$) and tended to have lower ADF TD than HC diets ($P = 0.06$). As level of DF increased, NDF and ADF TD had a cubic response with 20% CT diets having the highest values. HC diets decreased fecal output on DM and wet-bases, and DF had a decreasing linear effect on these parameters ($P \leq 0.01$). Urine volume excretion tended to be higher for HC-fed heifers (16.2 vs. 7.7 ± 2.51 kg/d; $P = 0.06$) and increasing level of DF tended to decrease urine output ($P = 0.10$). Total purine derivatives did not differ between treatments or CT level, but uric acid tended to be higher in HC-fed heifers ($P = 0.06$), and tended to decrease linearly ($P = 0.10$) when levels of DF increased. We conclude that CT decreased DM, and OM TD linearly while NDF, and ADF TD were maximized when 20% CT was added to HC and LC diets; HC diets were more digestible and generated less fecal output, but total manure was not different between HC or LC diets.

Key Words: high concentrate diet, fiber, limit-feeding, dairy heifer

569 Dietary starch level and dose response of *Saccharomyces cerevisiae* for limit fed-dairy heifers. G. J. Lascano*[1], J. M. Tricarico[2], and A. J. Heinrichs[1], [1]*The Pennsylvania State University*, *University Park*, [2]*Alltech Inc.*, *Nicholasville, KY*.

The objective of this experiment was to determine the effects of 2 levels of dietary starch and the dose at which the effects of *Saccharomyces cerevisiae* (Yea-Sacc[1026], Alltech Inc.; YC) are maximized based on nutrient total tract digestibility (AD), rumen fermentation, microbial protein synthesis, and N utilization of limit-fed dairy heifers. A split plot design with starch level as the whole plot and YC dose as sub-plot was administered in a 4 period (21 d) 4 × 4 Latin square. Eight Holstein heifers (432.49 ± 6.81 kg BW) were allocated to 2 starch treatments (30% starch: HS; 15% starch: LS) and to a sequence of YC doses (0, 10, 30, and 50 g/d). DM ($P = 0.98$) and NDF ($P = 0.28$) AD were not different between HS and LS; however, HS decreased ADF and increased hemicellulose AD (48.5 vs 44.9 ± 1.38 and 45.0 vs. 56.4 ± 3.20% respectively). YC dose increased DM AD quadratically (68.6, 68.8, 71.3, and 69.8 ± 0.47%; $P < 0.01$). NDF, ADF, and hemicellulose AD increased or tended to increase quadratically with increasing YC dose ($P = 0.03$, 0.06, 0.10 respectively). No significant effects were noted on fecal or urine output. Mean ruminal pH was higher for LS treatment (6.18 vs. 6.05 ± 0.06), and there was a trend ($P = 0.09$) for YC dose and starch interaction. The highest pH for LS and HS diet were at 0 and 50 g/d respectively. Total volatile fatty acid concentration was not different among YC doses or starch level. Concentrations of propionate, isobutyrate and iso-valerate were higher for HS than LS. Isovalerate was reduced linearly with increasing addition of YC and acetate: propionate responded quadratically to YC addition with 10 g/d having the lowest

value. Estimated microbial N outflow was not different among starch treatments or YC doses. We conclude that starch level did not affect DM AD, but influenced ADF and hemicellulose AD. YC dose had a greater effect on DM, NDF, ADF, and hemicellulose AD when added at 30 g/d. Fermentation parameters were not different among dietary treatments, but rumen pH was higher for LS diets.

Key Words: yeast culture, starch, limit-feeding, dairy heifer

570 Effects of limit-feeding on the feeding behavior of dairy heifers. B. L. Kitts*, B. W. McBride, I. J. H. Duncan, and T. J. DeVries, *Department of Animal and Poultry Science, University of Guelph, Kemptville Campus*, *Kemptville, Ontario, Canada*.

Limit-feeding replacement dairy heifers has been shown to control growth, while reducing feed costs and increasing efficiency; however, it also poses behavioral concerns. The objective of this study was to determine if these concerns are mitigated by providing straw alongside a limit-fed ration. Twenty-four Holstein dairy heifers (187 ± 11.3 d of age, 231.1 ± 12.0 kg), divided in groups of 4, were exposed to each of 3 treatments in a replicated Latin square design with 28-d periods. The treatment rations were: 1) TMR, 2) TMR with straw (2kg/d/heifer) offered as a choice (TMR-C) and 3) TMR with straw (2kg/d/heifer) mixed in (TMR-M). The TMR was fed at a restricted level (2.02% of BW) and contained (DM basis) 19.0% haylage, 21% corn silage, 45% high moisture corn, and 15% protein supplement. Feeding behavior was recorded for the last 14 d of each period. Standing time was recorded for the last 7 d of each period. Rumination behavior was recorded twice weekly in the last 14 d of each period. BW was recorded weekly and group DMI was recorded daily. Data were averaged per treatment per group, and analyzed in a GLMM with treatment, period and square as fixed effects and group within square as a random effect. DMI was lowest for the TMR treatment compared with the treatments with straw (5.7 vs 7.3kg/d; SE = 0.02, $P < 0.001$). Heifer ADG tended to be lower on the TMR-M compared with the TMR and TMR-C treatments (0.78 vs 0.94kg/d; SE = 0.04, $P = 0.1$). Feed efficiency (DMI/ADG) improved (SE = 0.01, $P < 0.001$) on the TMR (6.3) compared with TMR-C (7.8) and TMR-M (9.9). Daily feeding time differed (SE = 6.6; $P < 0.001$) between TMR (76.1 min/d), TMR-C (206.9 min/d), and TMR-M (279.2min/d). Inactive standing time differed between treatments (SE = 6.4; $P < 0.001$); with TMR being the highest compared with TMR-C and TMR-M (556.4 vs 409.9 vs 340.1 min/d). There tended to be fewer heifers ruminating on the TMR compared with TMR-M (14 vs 21.9%; SE = 2.0; $P = 0.1$). The results suggest that provision of straw as a choice, alongside a limit-fed ration, will allow heifer growth rates to be targeted, as well provide a suitable foraging source that heifers can use to satisfy their natural feeding behavior patterns.

Key Words: limit-feeding, dairy heifer, feeding behavior

571 Evaluation of potential carry over effects associated with limit feeding gravid Holstein heifers. K. A. Kruse*, N. M. Esser, P. C. Hoffman, and D. K. Combs, *University of Wisconsin, Madison*.

To evaluate potential carry over effects associated with limit feeding dairy heifers 96 Holstein heifers (400 ± 6 kg, 15.2 ± 0.1 mo) including 9 heifers with ruminal cannula were fed one of 3 dietary treatments for 180 ± 8 d in a randomized replicated pen design. Treatment diets included a control diet (C100) and 2 limit fed (LF) diets. The LF diets were formulated to provide similar nutrient intakes to C100. One LF diet (L85) was fed at 85% of C100 intake, and the other contained an ionophore (I; 325 mg/hd/d of Lasalocid) and was fed at 80% of C100 intake (L80+I). Heifers were evaluated for growth, rumen digesta volume, nutrient excretion and lactation performance. Data were analyzed using SAS proc mixed procedure with the replication of pen being the experimental unit. The LF heifers consumed less DM, NDF, and had greater ADG (0.96, 0.89 vs 0.81 kg/d), and lower feed:gain ratios (9.1, 9.3 vs. 13.0 kg/kg) as compared with heifers fed C100. No differences in rumen pH, NH_3-N, or VFA concentrations were observed between C100 or LF heifers. Limit fed heifers tended to excrete less DM (3.9, 3.2 vs 4.3 kg/d), whereas N and P excretion values were not different. Apparent N retention was improved in LF over C100 heifers (84.1, 96.8 vs. 77.1 g/d). Limit feeding did not alter rumen digesta volume, weight or density ($P > 0.05$). No differences were observed for dystocia index (≤1.0), calf BW (40.6 kg), or 7 d postpartum BW (566 kg) between LF and C100 fed heifers. After parturition, all heifers were fed a common high fiber diet. Lactation BW (551 kg), DMI (19.9 kg/d), and feed efficiency (1.6 kg/kg milk) were similar between treatments at 45 or 90 DIM. Milk yield (33.2 kg/d), milk fat (3.70%) and milk protein (2.90%) also were similar. At 45 DIM, rumen digesta volume was greater (99.1 vs. 66.1 L) for cows fed L85 as compared with cows fed L80 + I as heifers, but this effect was not observed at 90 DIM. Rumen digesta volume, lactation DMI, and milk yield of LF gravid Holstein heifers for 180 d did not result in negative carryover affects.

Key Words: limit feeding, heifers, ionophore