Ruminant Nutrition: Dairy: Fats and Carbohydrates

870 Insulin signal transduction in adipose tissue of peripartal dairy cows fed two levels of dietary energy prepartum. P. Ji*, J. S. Osorio, J. K. Drackley, and J. J. Loor, *University of Illinois*, *Urbana*.

Homeorhesis plays a major role in controlling nutrient partitioning from late prepartum through early lactation during which the fetus or mammary gland are the main targets of energy flow. Coincidently, the responsiveness of peripheral tissues such as adipose to insulin is diminished during early lactation. However, it remains unclear if prepartal dietary energy level affects adipose tissue responsiveness and what molecular mechanisms might be involved. To test the adipose responsiveness to insulin in late gestation, subcutaneous adipose tissue was biopsied at −10 and 7 d relative to parturition from dairy cows fed controlled energy (high straw, CE; NEL = 1.30 Mcal/kg) or moderate-energy (ME; NEL = 1.49 Mcal/kg) diets during the close-up period. Adipose tissue explants were initially incubated in DMEM medium at 37°C with 5% CO2 for 30 min as an adaptation period. Explants serving as negative controls were removed after adaptation. Remaining explants were transferred to wells containing fresh DMEM medium for a time-course (15, 30, or 60 min) insulin challenge (1 μg/L). Total cellular protein was isolated from duplicate explant cultures (both control and challenged) for quantification of tyrosine phosphorylation of IRS1 (IRS1-pY) and Thr308-phosphorylation of Akt (Akt-pThr308). IRS1-pY residue serves as the docking site for the SH2 domain of the protein, which mediates signal transduction of insulin; Akt is phosphorylated and activated in the Thr308 motif and plays a pivotal role in the PI3K pathway that is activated upon insulin stimulation. Total IRS1 phosphorylation was used to normalize the IRS1-pY data. Preliminary results revealed significant main effects of dietary energy level ($P < 0.01$) and incubation time ($P < 0.01$). IRS1-pY phosphorylation was higher in tissue from cows fed ME vs. CE after 15 min and 60 min, leading to a diet × time effect ($P < 0.05$). In tissue from cows fed CE, the response to insulin peaked at 30 min after challenge. Overall, results indicated that level of dietary energy affected the sensitivity of adipose tissue to exogenous insulin in vitro.

Key Words: Insulin response, IRS1, peripartal dairy cow

871 Duodenal infusion of α-linolenic acid affect fatty acids metabolism in mammary gland of lactating dairy cows. G. Yang, J. Q. Wang*, D. P. Bu, Khas-Erdene, Q. S. Liu, L. Y. Zhou, P. Sun, and K. L. Liu, *State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences*, *Beijing, P. R. China*.

Increasing the α-linolenic acid (LNA; 18:3 *cis*-9, *cis*-12, *cis*-15) plasma concentration might affect fatty acids (FA) metabolism in the mammary gland. Objective was to determine the effects different arterial concentration of 18:3 *cis*-9, *cis*-12, *cis*-15 (18:3n-3) would have on mammary uptake and synthesis of FA in lactating dairy cows duodenally infused with LNA, via arterial-rectificative venous concentration (AC-RVC) differences and mammary gland balance. Four primiparous lactating Chinese Holstein cows fitted with duodenal cannula were administered 2 treatments in a crossover design: rich-LNA fatty acid infusion at varying concentrations (0, 100, 200, 300, and 400 g/d) vs. basal infusate control. Arterial concentration of 18:3n-3 quadratically increased (29.24, 134.1, 218.3, 219.3, and 216.4 mg/L plasma) as LNA infusion levels increased from 0 to 400 g/d. The mammary extraction rate and uptake of 18:3n-3 was linearly increased as LNA infusion increased. The AC-RVC differences of 18:3n-3 and total FA increased more rapidly than arterial concentrations with all treatments. Increasing LNA infusion linearly increased the balances of 10:0 and 12:0, while linearly decreased the 14:1 and 15:0 balances, which suggested an inhibitory effect on termination process with 12 carbon during FA synthesis in mammary gland. Increasing arterial concentration of 18:3n-3 affects uptake and synthesis of FA in the mammary gland of lactating dairy cows. It is also suggested that the use of arterial-rectificative venous concentration differences maybe an acceptable way to investigate mammary gland metabolism of FA.

Key Words: α-linolenic acid, mammary gland metabolism, dairy cows

872 Effects of different rumen inert fatty acids on fermentation, anti-oxidative status, and microbiota in the rumen, in the absence or presence of dietary antioxidant. Y. M. Wang[1], J. H. Wang[1], C. Wang*[1], J. X. Liu[1], H. Cao[2], F. C. Guo[2], and M. Vázquez-Añón[3], [1]*Institute of Dairy Science, Zhejiang University*, *Hangzhou 310029, P.R China*, [2]*Novus International Research Center*, *Beijing 100085, P. R. China*, [3]*Novus International, Inc.*, *St. Louis, MO 63147, USA*.

In vitro gas test was employed to evaluate the effect of fatty acids of different degrees of saturation on rumen fermentation of sheep in vitro, in the absence or presence of dietary antioxidant (AOX; Agrado plus, Novus International). The experiment was carried out in a 2 × 2 factorial design, with fatty acid type (at 0 and 50% saturation) as one factor and AOX (0 or 500 mg/kg) as another one. Calcium salt of long-chain fatty acids (50% unsaturated fatty acids, UFA) was supplemented as a source of UFA, and palm acid was supplemented as the source of saturated fatty acid (SFA). Substrate consisted of 100 mg corn powder and 100 mg Chinese wild ryegrass hay. Fermentation patterns and anti-oxidative status were not affected by fatty acid type. Inclusion of UFA significantly increased the populations of protozoa relative to total bacterial 16S rDNA, but showed negative effect on *Fibrobacter succinogenes*. Addition of AOX significantly increased gas production and organic matter digestion at 24h incubation. Molar proportion of propionate tended to increase at the expense of acetate due to AOX addition. Addition of AOX tended to decrease malondialdehyde value and increase superoxide dismutase activity. An interaction between AOX and fatty acid type was observed on *Ruminococcus flavefaciens* and *R. albus*. Addition of AOX to UFA-treated substrate significantly increased these 2 bacteria, but not in SFA treatment. In summary, supplementation of UFA results in inferior effect on fiber-digesting bacteria, while this negative effect can be alleviated by AOX addition, but not in SFA treatment. Rumen fermentation and anti-oxidative status tended to be improved by AOX addition, regardless of the fatty acid type.

Key Words: fatty acid type, antioxidant, rumen fermentation

873 Incorporation of essential and non-essential fatty acid into distinct lipid classes in cultured bovine and porcine liver slices. C. Caldari-Torres*, A. J. Lengi, M. L. McGilliard, D. M. Shepherd, J. A. Stamey, and B. A. Corl, *Virginia Polytechnic Institute and State University*, *Blacksburg*.

Ruminants, compared with non-ruminants, segregate fatty acids into specific lipid classes, allowing for essential fatty acid (EFA) conservation. The mechanisms involved in this selective esterification of fatty acids (FA) remain undefined. The aim of this study was to examine FA esterification patterns in ruminant and non-ruminant liver slices. We performed in vitro culture of bovine and porcine liver slices with radiolabeled FA to track esterification of EFA and non-EFA into lipid

classes. Liver slices were incubated in media containing radiolabeled non-EFA ([1-^{14}C]16:0 or [1-^{14}C]C18:1), or EFA ([1-^{14}C]C18:2 or [1-^{14}C] C18:3). In a preliminary study C18:1 incorporation by bovine liver slices increased linearly with time ($R^2 = 0.95$, $P < 0.001$) and tissue weight ($R^2 = 0.96$, $P < 0.001$). Mean FA incorporation was higher for porcine than for bovine liver slices (23.9 versus 15.9 ± 1.8 nmol•2 h^{-1}•150 mg $tissue^{-1}$, $P = 0.03$). Liver cultures of both pig and cattle incorporated non-EFA more readily than EFA (22.9 vs 16.9 ± 1.6 nmol•2 h^{-1}•150 mg $tissue^{-1}$, $P < 0.001$). Pigs esterified a higher proportion of FA into triglycerides (TG) than phospholipids (PL) (3.7 vs. 2.2 ± 0.3 nmol•2 h^{-1}•150 mg $tissue^{-1}$, $P < 0.001$). Cattle did not exhibit preferential esterification of FA into either lipid class, but esterified more non-EFA into TG compared with PL (1.3 vs. 0.9 ± 0.3 nmol•2 h^{-1}•150 mg $tissue^{-1}$, $P = 0.002$). A higher proportion of EFA than non-EFA was incorporated into PL by cultured bovine liver slices (1.4 vs. 0.9 ± 0.3 nmol•2 h^{-1}•150 mg $tissue^{-1}$, $P = 0.02$). There were no differences in esterification patterns of EFA and non-EFA into the TG lipid class of cattle, or the PL or TG lipid classes of pigs. An increase in PL/TG ratio was observed when bovine liver slices were cultured with EFA, compared with non-EFA (1.09 vs. 0.69 ± 0.1 nmol•2 h^{-1}•150 mg $tissue^{-1}$, $P = 0.001$). There was no difference in PL/TG ratio in porcine liver slices cultured with EFA or non-EFA. Results suggest that liver esterification patterns of cattle and pigs differ, with esterification patterns of ruminants possibly facilitating greater EFA esterification into PL.

Key Words: fatty acid, liver, cattle

874 Effects of feeding increasing levels of concentrate on milk fatty acid composition in grazing dairy cows. L. Antonacci[1], G. A. Gagliostro*[1], V. I. Cejas[2], and M. A. Rodriguez[2], [1]*Instituto Nacional de Tecnología Agropecuaria (INTA)*, *Balcarce, Provincia de Buenos Aires, Argentina*, [2]*Instituto Nacional de Tecnología Industrial (INTI)*, *San Martín, Buenos Aires, Argentina*.

Increased intake of concentrate may shift rumen biohydrogenation of C18:3 and C18:2 fatty acids (FA) toward 10t C18:1 reducing the t11 C18:1 (VA) and 9c, 11t C18:2 (CLA) contents in milk. Twelve Holstein cows grazing spring pastures (alfalfa 70%, orchardgrass 30%) were blocked by days in milk (DIM) and randomly assigned to 3 treatments in a replicated Latin square. At the start of the experiment the 6 cows from square 1 (514 kg LW) were producing 28.2 kg milk/d and averaged 35 DIM. In Square 2, LW, milk yield and DIM were 554 kg, 31.3 kg/d and 197 d respectively. Periods lasted 19 d., the first 14 d as adaptation and the last 5 d for sampling period. Treatments (C3, C6, and C9) were 3 levels (3, 6, and 9 kg/d) of concentrate (90.4% DM) containing (g/kg DM) CP (160), starch (351), soluble carbohydrates (149), ether extract (39.7) and NDF (248). Supplements were thoroughly consumed by cows. Data were analyzed with effect of square, period, cow within square; treatment, interaction between period and treatment (NS) and residual error. Cows from C9 produced more milk (27.5 vs. 23.6 kg/d) and protein (885 vs. 735 g/d) compared with C3 ($P < 0.05$) without depressing milk fat content (29.9 g/kg) or pasture intake (11.94 kg DM/cow/d) ($P < 0.69$). Concentration (g/100g FA) of de novo (C4:0-C15:1, 21.78), preformed (>17:0, 48.2), saturated (59,41) or unsaturated (40.34) FAs were not affected whereas that of t10 C18:1 resulted lower ($P < 0.03$) in C9 (0.52) compared with C6 (0.59) and C3 (0.58). Milk fat content (g/100g FA) of VA (3.23; 3.76 and 3.72) and CLA (1.93; 2.01 and 1.92) resulted high in all treatments (C3, C6 and C9) and not affected by concentrate intake ($P > 0.24$). The atherogenicity index of milk fat averaged 1.84 (±0.12) across treatments ($P > 0.77$). When pasture represented from 82 to 58% of total DM intake of cows increasing concentrate intake from 3 to 9 kg/cow/d had only minor effects on t10 C18:1 concentration in milk without depressing VA and CLA contents.

Key Words: grazing dairy cows, concentrate levels, milk fatty acid

875 Effects of dietary fat supplements and forage:concentrate on feed intake, feeding and chewing behavior of Holstein dairy cows. S. Kargar, M. Khorvash, M. Alikhani, and G. R. Ghorbani*, *Isfahan University of Technology*, *Isfahan, Iran*.

Hydrogenated palm oil and yellow grease as saturated and unsaturated fat supplements, respectively, were investigated for effects on feed intake, diurnal fluctuation of eating and ruminating, meal patterns, and chewing behavior. Eight multiparous Holstein dairy cows were used in a replicated 4 × 4 Latin square experiment with 21 d periods. Treatments were 1) no supplemental fat and 34:66 forage:concentrate (F:C) ratio (Control), 2) 2% hydrogenated palm oil and 34:66 F:C ratio (HPO), 3) 2% yellow grease and 34:66 F:C ratio (YG), and 4) 2% yellow grease and 45:55 F:C ratio (YGHF). All data were analyzed using the MIXED procedure of SAS (SAS, 2003). Preplanned statistical contrasts were used to test the effect of fat supplementation (Control vs. HPO + YG); the effect of source of fat supplement (HPO vs. YG); and the effect of forage to concentrate ratio within diets supplemented with yellow grease (YG vs. YGHF). Dry matter intake (DMI) was not affected by fat supplementation regardless of type of fat (27.0 ± 1.11; $P = 0.81$), but cows fed diets with larger F:C ratio ate 7.5% less (25.3 vs. 27.2 ± 1.11; $P \leq 0.002$) . There were no treatment effects on meal patterns by fat supplementation (15.0 ± 0.9; $P = 0.76$), source of fat (15.0 ± 0.9; $P = 0.26$), and F:C ratio (16.0 ± 0.9; $P = 0.41$) but intermeal interval (69.0 ± 4.8; $P \leq 0.04$), eating rate (0.074 ± 0.004; $P \leq 0.03$), and meal size (1.76 ± 0.12; $P \leq 0.001$) were lower in cows fed yellow grease and eating rate was less for the diet with greater NDF content (0.064 ± 0.004; $P \leq 0.001$). Total chewing time (minutes per kilogram of DMI) was not affected by fat feeding (29.9 ± 1.6; $P = 0.85$) nor type of fat supplementation (29.9 vs. 29.8 ± 1.6; $P = 0.93$) but was more for the diet with greater F:C ratio and NDF content (34 ± 1.6; $P \leq 0.01$). In the current study, DMI was not decreased while meal size decreased. Our findings agree with the conclusion that chewing activity might be determined largely by dietary forage NDF content.

Key Words: chewing behavior, forage to concentrate ratio, fat

876 Effects of rapidly rumen fermentable source of starch in prepartum diet on metabolism and performance of multiparous Holstein cows during the periparturient period. H. R. M. Alamouti*[1], H. Amanlou[1], and K. Rezayazdi[2], [1]*University of Zanjan*, *Zanjan, Iran*, [2]*University of Tehran*, *Karaj, Tehran, Iran*.

Thirty-four multiparous Holstein cows were used in a completely randomized design and assigned to 1 of 2 treatments to evaluate the effects of 2 diets varying in ruminal fermentable source of starch, namely ground corn (GC) and rolled wheat (RW), on metabolism and performance of multiparous cows in the periparturient period. The cows were fed diets as a total mixed ration (TMR) with similar energy and crude protein content including 1) 185.7g/kg GC, or 2) 185.7g/kg RW from −22.10 ± 7.1 d relative to expected calving until calving. After calving, all cows received the same lactation diet until 28 d. Cows were group fed from the beginning of the study to −7 d relative to expected calving, fed individually from d −7 to 7 d in milk (DIM), and again group fed to 28 DIM. Dry matter intake (DMI), energy intake, energy balance (EB) and body condition score (BCS) were not different between treatments. The pre-partum diets affected ($P < 0.05$) urinary pH during the last week pre-partum. The RW diet increased ruminal propionate concentration

compared with the GC diet in periparturient period. There was no effect of pre-partum starch source on overall plasma concentration of glucose, nonesterified fatty acid (NEFA), β-hydroxybutyrate (BHBA), albumin, triglyceride (TG), cholesterol, aspartate aminotransferase (AST), insulin, and cortisol during the periparturient period. Cows fed the RW diet during the pre-partum period had greater calcium during 28 d ($P = 0.09$) of lactation compared with cows fed the GC diet. Multiparous cows fed the RW diet produced greater milk protein content ($P = 0.08$). Multiparous cows fed the RW diet had lower milk urea nitrogen (MUN) than cows fed the GC diet ($P < 0.05$). The results of this study show that a rapidly fermentable source of starch (wheat grain) can be included in pre-partum diets without compromising dairy cow metabolism and performance and can smooth the transition of multiparous Holstein cows from gestation to lactation.

Key Words: periparturient period, rapidly fermentable carbohydrates, Holstein cows

877 Effects of cereal grain level in early lactating diets on metabolism and performance of Holstein cows. H. amanlou[1], N. Fazli[1], S. S. Mosavi[1], H. R. Mirzaei Alamouti*[1], and M. Moeini[2], [1]*University of Zanjan*, *Zanjan, Iran*, [2]*Abhar Islamic Azad University*, *Zanjan, Abhar, Iran*.

Acidosis is a major constraint in consumption of cereal grains (CG) in early lactating Holstein dairy cows diet. The objective of this study was to determine effects of CG (corn + barley mix) levels in early lactating cows diet on dry matter intake (DMI), milk yield and contents, chewing activity, apparent dry matter digestibility and plasma metabolites concentration. Sixteen multiparous Holstein cow, body weight (BW), 605 ± 25.82 kg and body condition score (BCS), 3.09 ± 0.06, were used in a completely randomized design and assigned to 3 diets; 1) 31% CG and 38% nonfiber carbohydrate (NFC), 2) 25.5% CG and 35.5% NFC and 3) 20% CG and 33% NFC. Cows were individually fed the total mixed ration with similar net energy for lactation (1.7 Mcal/kg) and crude protein (19.2%) from 20 ± 2.2 d in milk during 6 week. Milk yield and content were determined 3 times per day. Daily DMI and weekly nutrient intake were determined. Blood was sampled into heparinized tubes from the coccygeal vein at the beginning and final day of the study and plasma metabolites were measured. Data were analyzed using MIXED Procedure from SAS and cows nested in the diets were as random effects. Different variance-covariance error structures were tested. No significant differences observed between the diets in DMI, BCS, BW and apparent dry matter digestibility. Cows fed the diet 3 had lower ($P < 0.01$) chewing activity than the others diets. Milk yield; 31.4, 36.2 and 39.4, milk fat percentage; 3.7, 3.09 and 3.46, for the diets 1, 2 and 3, respectively, and milk fat and lactose yield were significantly ($P < 0.05$) different between the diets. Plasma glucose concentration was lower ($P < 0.05$) in cows fed the diet 3 than the diets 1 and 2 (58.34 vs. 66.6 and 65.8 mg/dL). Plasma concentration of calcium, phosphorous, total protein, albumin and nonesterified fatty acids were not different. In summery, this study showed that cereal grains can be replaced with byproduct feeds high in digestible fiber in early lactating dairy cow diets without compromising lactation performance and metabolism.

Key Words: early lactation, cereal grain, Holstein cow