622 Effect of rumen protected conjugated linoleic acid on energy metabolism of dairy cows during early to mid-lactation. K. J. Shingfield1, D. E. Beever1, C. K. Reynolds1, S. K. Gulati1, D. J. Humphries1, B. Lupoli1, G. Hervas1, and M. J. Griinari2, 1Centre for Dairy Research, University of Reading, Reading, UK, 2University of Sydney, Sydney, Australia, 3Rumentek Pty Limited, Australia, 4University of Helsinki, Helsinki, Finland.

Trans-10, cis-12 conjugated linoleic acid (CLA) inhibits milk fat synthesis and reduces milk energy content. Controlled decreases in milk energy secretion could be used to improve energy balance of the dairy cow during early lactation. Twelve multi-parous Holstein-British Friesian cows were used in a randomized block study to evaluate the effects of rumen protected CLA (RCLA) on energy metabolism in early lactation. Supplements were prepared by casein-formaldehyde treatment of CLA methyl esters containing equal amounts of cis-9, trans-11 and trans-10, cis-12. At calving, cows were paired and allocated at random to a control diet (C) or the same diet supplemented with 110 g of RCLA that supplied 14.3 g trans-10, cis-12 CLA/d. Energy balance (MJ/d) was estimated during weeks 3, 7, 11 and 15 of lactation using 6d excreta collection and respiration calorimetry. On average, RCLA reduced milk fat content (34.9 vs. 19.2 g/kg; P<0.001) and milk yield (1395 vs. 901 g/d; P<0.001), increased (P<0.05) milk yield (40.3 vs. 47.4 kg/d) and milk protein output (1.25 vs. 1.42 kg/d) and tended to increase DMI (22.2 vs. 24.6 kg/d; P=0.06) and BW (614 vs. 661 kg; P=0.11). The effects on DMI and production occurred within one week of lactation. RCLA increased (P=0.08) energy intake (389 vs. 434, for C vs. RCLA, respectively), but had no effect (P=0.10) on estimated heat energy (155 vs. 169), milk energy (112 vs. 103) or energy excreted in methane (25.0 vs. 26.0), urine (11.1 vs. 11.0) or feces (108 vs. 119). However, RCLA improved (P<0.05) tissue energy balance (-17.1, 8.5, 6.6 and 24.4 at weeks 3, 7, 11 and 15 of lactation, respectively) compared with C (-53.1, -19.3, -8.2 and -6.5). In conclusion, RCLA decreased milk fat content, increased milk production and improved tissue energy balance of dairy cows during the first 15 weeks of lactation, with evidence of improved tissue N retention (19 vs. 42 g/d; P=0.05). In contrast to the effects in growing mice, heat energy/BW,75 was not affected (1.26 vs. 1.30).

Key Words: Conjugated Linoleic Acid, Energy Metabolism, Dairy Cows

624 Effects of source and level of dietary lipid on in vitro production of conjugated linoleic acid and trans vaccenic acid. X. Qiu1, K. E. Griswold2, G. A. Aggar3, D. W. Murdoch1, E. D. Frantz1, D. L. Hastings2, and B. N. Jacobson1, 1Southern Illinois University, Carbondale, 2Penn State University Extension, Lancaster.

Two in vitro experiments were conducted to investigate the effects of source and level of lipid on biohydrogenation (BH) and the production of conjugated linoleic acid (CLA) and trans vaccenic acid (TVA). Exp. 1 examined the effect of partial (50%) or complete replacement of 4% yeast meal with each of the following three plant oils: soybean oil, corn oil, and sunflower oil (SUO), respectively. Based on the results of Exp 1, Exp 2 with a total of six treatments was designed to investigate the effects of four other plant oil sources, olive oil, peanut oil, canola oil, and safflower oil (SAO), as compared to yellow grease and SUO at 4% of dietary DM. Diets were composed of corn silage, alfalfa hay, soybean meal, and contained 18.4% CP and 32.4% NDF on average. Three samples were incubated per treatment per time point. Fatty acid data were analyzed using the MIXED procedure of SAS with repeated measures. Rate of BH was estimated by linear regression. In Exp. 1, source of lipid did not affect the production of TVA but affected (P<0.05) the production of CLA isomers and total CLA, with SUO producing the largest increase in TVA and CLA yields; elevated level of plant oil increased the production of TVA (P<0.05), total CLA (P<0.01) and CLA isomers (P<0.01). In Exp. 2, SUO and SAO were similarly effective (P<0.01) in increasing TVA production compared to other plant oils. However, SAO was more effective (P<0.01) than SUO in increasing CLA production and SUO (P<0.01) was more effective than the other oils. In addition, combined information from both experiments showed that, within the range of 4% of dietary DM, rate of BH was not affected by lipid source but slightly increased as oil level increased; production of CLA peaked between 12 and 18 h, whereas the peak for TVA occurred later, around 24 h.

Key Words: Conjugated Linoleic Acid, Vaccum Acid, In vitro
Diets producing MFD alter pathways of rumen biohydrogenation, resulting in decreased biohydrogenation of ruminal undecenoic acid (18:1). Increased trans-10 C18:1 formation is a consistent observation. Furthermore, trans-10 C18:1 is often associated with formation of trans-10, cis-12 CLA, a precursor of trans-10 C18:1. Fish oil (FO)-induced MFD represents a notable deviation since it is associated with increased formation of trans-10 C18:1 without any increase in milk trans-10, cis-12 CLA content. This study evaluated temporal changes in secretion and fatty acid profile of milk fat in response to FO and low dietary fiber. Midlactation Holstein cows were used. The study was conducted in three periods: 1) Baseline: all cows (n=12) received high fiber diet (HF) without FO (baseline diet, BD) for 12 d; 2) Supplementation: cows (n=4) received three treatments for 21 d: a) HF+FO, b) Low fibre diet (LF) and c) LF+FO; 3) Post-supplementation: all cows returned to BD on 12 d. NDF contents of HF and LF were 40 and 25%, respectively. Roughage was corn silage and FO was included at 1.6% of DM. Milk fat content was progressively reduced for the first two weeks of FO supplementation, after which it reached a plateau. Co-variate adjusted LS-means for milk yield and content were 0.74a, 0.45b and 0.44b kg/d and 3.88a, 2.83b and 2.60b% for LF, HF+FO and LF+FO, respectively (different superscripts, P<0.05). Milk trans-10, cis-12 CLA content was unchanged by dietary treatments. However, trans-10 C18:1 and cis-12 C18:1 contents increased in FO supplemented diets (P<0.05). Temporal change in milk fat content was more closely associated with cis-12 C18:1 than trans-10 C18:1. We conclude that formation of cis-12 C18:1 is characteristic of the altered rumen biohydrogenation and a putative product of linoleic acid associated with FO-induced MFD.

Key Words: Fish Oil, Conjugated Linoleic Acid, Milk Fat Deposition

628 Kinetic model of rumen biohydrogenation: effects of rumen-protected fatty acid saturation on fractional rate of biohydrogenation and duodenal fatty acid flow in lactating dairy cows. K. J. Harvatine* and M. S. Allen, Michigan State University, East Lansing.

A simple model of rumen fatty acid (FA) metabolism is proposed that allows calculations of first order fractional rate of FA biohydrogenation and FA passage after determination of ruminal FA pool size and duodenal flux. Saturated and unsaturated rumen-protected fatty acid sources were evaluated for effects on fractional rate and extent of rumen biohydrogenation and duodenal FA flow. Eight ruminally and duodenally cannulated multiparous Holstein cows (77±12 DIM, mean±SD) were used in a replicated 4×4 Latin square design with 21 d periods. Treatments were control and a linear titration of 2.5% added rumen-protected FA varying in saturation: saturated (SAT; prilled hydrogenated free FA, Energy Booster 100®), intermediate mix of SAT and unsaturated (UNS; calcium soaps of long-chain FA, Megalac-R®), and unsaturated (UNS). Experimental diets were 40% forage and contained 27.5% NDF, 30% starch, and 2.5% rumen available vegetable oil (13.5% cottonseed). Rumen-protected FA increased rumen FA turnover rate. Passage rates of C16:0, C18:0 and total C18 were linearly decreased with increasing UNS and trans-18:1 fractional passage rate was quadratically affected with a maximum for the intermediate treatment. Increasing UNS increased extent of C18:2 and C18:3 biohydrogenation and decreased extent of 18:1 and trans-18:1 biohydrogenation, resulting in increased duodenal flow of trans-C18:1. Calcium salts failed to protect polysaturated FA from rumen biohydrogenation despite a mean ruminal pH of 6.0. This model allows a mechanistic description of rumen biohydrogenation and determination of extent of C18:1 biohydrogenation.

Key Words: Biohydrogenation, Kinetic, Fatty Acid
Effect of rumen-protected fatty acid saturation on feed intake and feeding and chewing behavior of lactating dairy cows. K. J. Harvatine* and M. S. Allen, Michigan State University, East Lansing.

Saturated and unsaturated rumen-protected fat sources were evaluated for effects on feed intake, meal patterns and chewing behavior. Eight rumenally and duodenally cannulated cows (77 ± 12 DM, mean ± SD) were used in a replicated 4x4 Latin square design with 21 d periods. Treatments were control and a linear titration of 2.5% added rumen-protected fatty acids (RPF) varying in unsaturation: saturated (SAT; prilled hydrogenated free FA, Energy Booster 100®), 50:50 ratio of SAT and unsaturated (UNS; calcium soaps of long-chain FA, Megalac-R®), and UNS. Experimental diets were 40% forage and contained 27.5% NDF, 30% starch, and 2.5% rumen available vegetable oil (13.5% cottonseed). Dry matter intake for SAT was not different from control while UNS linearly decreased DMI 3.2 kg. Wet weight of ruminal digesta decreased linearly up to 11.3 kg (13%) with increasing UNS. Adding RPF did not change meal number, meal length or time between meals compared to control, but increasing UNS decreased meal size 0.22 kg (9%) within RPF. SAT increased time spent ruminating 56 (10%) and 42 (7%) minutes/d compared to CON and UNS respectively. Increasing SAT did not change rumination bout frequency or interval between bouts, but increased rumination bout length 5.6 min compared to UNS. Water intake was not affected by treatment, but increasing SAT linearly decreased the number of drinking bouts per day up to 2.9 (25%) bouts. Increased unsaturated FA flow to the duodenum decreased feed intake by decreasing meal size, and increased saturated FA flow to the duodenum increased rumination time per day by increasing rumination bout length.

Key Words: Rumination, Feeding Behavior, Fatty Acid


Eight lactating, multiparous Holstein cows with ruminal cannulas were blocked by DIM (block 1, 162 ± 20 DIM; block 2, 101 ± 16 DIM) in a replicated 4 x 4 Latin square design. During each 14-d period, treatments consisted of: 1) water infusion, ad libitum DMI (WA), 2) water infusion, restricted DMI (WR), 3) carnitine infusion, ad libitum DMI (CA), and 4) carnitine infusion, restricted DMI (CR). All cows received water infusion (1.2 L/d) during d 1-4 and either water or carnitine infusion during d 5-14. Infusions occurred at 0600, 1200, 1800, and 2400 h. Feed restriction (50% of previous 5-d DMI) began on d 10 due to DMI restriction (DMI x d; P < 0.01). During feed restriction, CR (30.0 kg/d) tended to maintain 3.5% FCM (infusion x DMI; P = 0.07) relative to WR (27.6 kg/d). Feed restriction increased plasma NEFA (DMI x d; P < 0.01), while CR decreased NEFA compared to DMI WR (infusion x DMI d x h; P < 0.01). Serum BHBA was higher for CR than WR, but similar between CR and CA (infusion x DMI d x h; P = 0.01) on d 12. Serum insulin was lower on d 12 due to DMI restriction (DMI x d; P = 0.01). Carnitine infusion increased (P < 0.01) the concentration of total carnitine in plasma compared with water infusion. Carnitine supplied postprandially improved metabolic responses to negative energy and nutrient balances induced by DMI restriction.

Key Words: L-carnitine, Metabolism, Milk Yield

Cholecystokinin mediates intake regulation of high fat diets in ruminants by acting on the reticulo-omasal sphincter. D. Kumar, M. A. Froetscher, T. D. Pringle, and D. H. Keiser, 1The University of Georgia, Athens, 2University of Missouri, Columbia.

Four yearling (320 kg) and four mature (650 kg) ruminally-fistulated Holstein steers were used in two, simultaneously run 4X4 Latin square designed trials to investigate the role of CCK and leptin in intake regulation of cattle fed high fat diets. Steers were fed diets containing 0, 3, 6, or 9% supplemental fat. Megalac was substituted for corn in high fat diets. All diets were formulated to contain 16.5% CP and 38.5% RUP. Diets contained concentrate and chopped Bermudagrass hay in the ratio of 2:1 and were fed once daily. Experimental periods were 10 days in length. On d 9, rumens were evacuated before feeding and again 6 h afterwards. Rumen contents were weighed, sampled and immediately replaced to provide estimates of rumen particulate disappearance rates. Reticularumenter motility was measured 1-3 h after feeding. Reticulo- omasal orifice opening time was measured only in yearling steers. Jugular blood samples were collected every 30 min, 1 h before and 3 h after feeding. Blood samples were analyzed for leptin, insulin, and glucose. On d 10, all procedures on d 9 were repeated except devazepide (70µg/kg BW), a CCK-A receptor antagonist, was injected into the jugular vein 1 h after feeding. Dietary fat decreased DMI 10.6 - 13.1% (Linear, P<0.05) in both yearling and mature steers. Yearling steers ate more as a percent of body weight as compared to mature steers (2.94 % VS 2.14%). Devazepide did not influence DMI. Dietary fat had no effect on reticulopa rumen motility, but devazepide increased motility irrespective of dietary treatment. Dietary fat decreased reticulo-omasal orifice opening time by 7.3 to 33.6% (Linear, P<0.05) in yearling steers and this effect was blocked by devazepide. Dietary fat decreased disappearance of ruminal digesta in yearling steers and this effect was blocked by devazepide. Neither dietary fat, devazepide or steer maturity affected leptin, insulin, or glucose. This data suggests that CCK-A is involved in regulating activity of the reticulo-omasal sphincter, thereby influencing reticulo-ruminal passage and mediating intake of ruminants fed dietary fat.

Key Words: Intake, Fat, Cholecystokinin
Objectives were to evaluate the effects of Ca salts differing in fatty acid profile on uterine involution and reproduction of dairy cows. After blocking according to parity, BCS at dry off and previous lactation milk production, 397 Holstein cows were randomly assigned to one of the two treatments consisting of Ca salts (2% diet DM) of either PO or LTFA from 23 d prepartum to 70 DIM. Body condition of all cows was scored at -43, -23, calving, and at 40, 70, 100 and 140 DIM. Blood was sampled during the first 21d postpartum four times weekly from a subset of 60 cows and plasma was analyzed for PGF metabolite. Ultrasound examination was performed weekly from 14 to 42 DIM to determine uterine diameter, thickness of the uterine wall, presence of fluid and interval to first ovulation. Cows were timed inseminated following the Ovsynch protocol at 72 DIM. Continuous and binomial data were analyzed by the MIXED and LOGISTIC procedures of the SAS (2001) program. Source of fatty acids had no effect on BCS either pre- or postpartum (P<0.40). Incidence of retained placenta (6.5 vs 6.7 %) and interval from calving to first postpartum CL (27.9 vs 28.3 d) did not differ (P=0.15) between PO and LTFA, respectively. Interval from calving to disappearance of uterine fluid was reduced in cows fed LTFA compared to PO (27.6 vs 25.8 d; P=0.04). Pregnancy rate after first postpartum AI tended to be higher for LTFA than PO at 27 (36.1 vs 28.1%; P=0.09) and 41 (33.5 vs 25.6%; P=0.09) d after AI, but pregnancy losses were similar (P=0.74) and averaged 7.9%. Ca salts differing in fatty acid profile affected reproduction of dairy cows. Supported by NRI/USDA Grant 2003-02742.

Key Words: Reproduction, Fatty Acids, Dairy Cows

343 Responses of milk fat composition to dietary non-fiber carbohydrates in Sarda dairy sheep. A. Nudda*, S. Fancellu, F. Porcu, F. Boe, and A. Cannas. Dipartimento di Scienze Zootecniche, University of Sassari, Italy.

Diet with high concentration of non-fiber carbohydrates (NFC) often induce milk fat depression (MFD) and changes in the fatty acid (FA) composition of milk in cows. In sheep MFD is less common, even when high NFC diets are fed at very high levels of intake or when they are supplemented with unsaturated oil. However, there are very few studies on sheep milk fatty acid composition for these diets. For this reason, an experiment was carried out to study the effect of diets with high (43% of DM) and low (28% of DM) NFC concentration on fat content and FA composition in sheep milk. Ten Sarda dairy sheep in mid lactation were individually fed ad libitum diets that contained 56% of finely chopped kikuyu based pasture, were fed RP-CLA alone (61.5g/d equivalent to 10.3g/d trans10, cis12 and 10.2g/d of cis9, trans11) for 4 days followed by a combination of RP-CLA and RP-soybean/canola oilseeds as oilseeds/meals. Five Holstein cows in mid-lactation, grazing a predominantly kikuyu based pasture, were fed RP-CLA alone (61.5g/d equivalent to 10.3g/d trans10, cis12 and 10.2g/d of cis9, trans11) for 4 days followed by a combination of RP-CLA and RP-soybean/canola oilseeds, the latter providing 656g of additional fat per day. RP-CLA alone reduced milk fat by 30% (from 4.2% to 2.9%; P<0.001) and fat secretion by 28% (from 826g/d to 594g/d; P<0.001). In combination with RP-soybean/canola oilseeds, milk fat increased from 2.4% to 3.4% (P<0.001) and fat secretion was enhanced from 594g/d to 858g/d (P<0.001). This result indicates that the mechanism of CLA induced milk fat depression occurs primarily in the lipogenic pathways within the mammary gland and not on the uptake and transfer of circulating fatty acids. From a dairy industry perspective, it is now practical to design and feed RP fat/protein supplements that produce beneficial effects on performance and product quality.

Key Words: Rumen Protected Oilseeds, CLA

356 Effect of GnRH in conjunction with ram introduction on the induction of fertile estrus during the non-breeding season. K. M. Jordan*, R. L. A. Cerri, R. Bruno1, K. N. Galvão1, E. W. Lemos1, M. Villasenon1, A. C. Cosci1, S. M. Pavan1, J. E. P. Santos1, M. M. Lacerda-Jr1, S. O. Juchem1, A. Nudda*, S. Fancellu, F. Porcu, F. Boe, and A. Cannas. Division of Animal and Veterinary Sciences, University of Sassari, Italy. Division of Animal and Veterinary Sciences, University of Sassari, Italy. Division of Animal and Veterinary Sciences, University of Sassari, Italy. Division of Animal and Veterinary Sciences, University of Sassari, Italy. Division of Animal and Veterinary Sciences, University of Sassari, Italy.

Introduction of novel rams to anestrous ewes, the ram effect, can be used as a tool for out-of-season breeding but produces a variable response. A single injection of progesterone at ram introduction (RI) and treatment with PG on d12-16 improved the proportion of pregnant ewes. Maintenance of the ram-induced corpus luteum (CL) up to PG treatment is probably crucial to success of this procedure. Therefore, the effect of a GnRH injection in conjunction with RI was evaluated in ewes. In addition, the effect of presence of a CL prior to PG injection on fertility of anestrous ewes was tested. In early July, ewes (n = 28-32/group) were exposed to intact rams for 35d and given an ovulatory dose of GnRH (100µg) on d2, d7 or both days following RI. The presence of a CL was determined by transrectal ultrasonography on d7 and d14 at which time an injection of 20 mg PG (Lutalyse) was given. Pregnancy was diagnosed on d52 and d67 relative to RI. Mean estrous response (56%), pregnancy rate to the first (PR1; 29%) and second (PR2; 65%) service periods did not differ among groups. Because of potential for a CL induced by RI or GnRH to be short-lived, the effect of presence of a CL on d7 and/or d14 on fertility variables was examined. Ewes were reclasified as having: no CL on d7 or 14 (CL 0; n=14), a CL on d7 only (CL 7; n=10), a CL on d14 only (CL 14; n=16), or a CL on both days (CL 7,14; n=16). More ewes (P<0.01) in CL 7 (70%), CL 14 (81%) and CL 7,14 (81%) were marked by rams than in CL 0 (14%). PR1 and PR2 were greater in ewes in CL 7,14 (53 and 81%) and CL 14 (38 and 93%) than in CL 0 (7 and 38%). PR1 tended to be higher (P = 0.06)