INFLUENCE OF *PRE-PARTUM* FEEDING ON PERIPARTURIENT METABOLIC STATUS IN ESTONIAN HOLSTEIN COWS

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Summary. Increasing cows' dry matter intake, or using more energy-dense diets prior to parturition, may prevent excessive lipid mobilization around parturition. On the other hand, feeding energy-dense diets for a prolonged time may lead to overconditioning at parturition followed by depressed appetite, reduced intake and more extensive lipid mobilization. The aim of the present study was to examine effects of *pre-partum* feeding on periparturient metabolic status in Estonian Holstein cows. Two weeks *pre-partum* (w-2, w-1) differing amounts of a one concentrate were fed to a Low (L) and a High (H) group while the same amount of another concentrate was fed during the first four weeks *post-partum* (w1, w2, w3, w4). Silage was available *ad-libitum* during the whole experimental period. Blood samples, obtained from the coccygeal vein on w-2, w-1, w1, w2, w3 and w4 were analyzed for aspartate aminotransferase (AST) activity and urea, glucose, ketone bodies, triglycerides, non-esterified fatty acids (NEFA), total cholesterol, insulin and glucagon concentrations. The repeated measures general linear model analyses with the SAS system MIXED procedure were performed to discover the influence of *pre-partum* feeding on blood metabolites. Blood urea concentration tended to be higher in group H on w-1 (P=0.06) and w2 (P=0.06); NEFA concentration was higher in group L on w-2 (P=0.01) and w3 (P=0.02), and tended to be higher on w-1 (P=0.08) and w2 (P=0.08); ketone bodies concentration was higher in group L on w1 (P=0.0001) and glucagon concentration was higher in group L on w1 (P=0.03) and w2 (P=0.02), and tended to be higher on w-1 (P=0.08) and w4 (P=0.06). There were no significant differences between the groups' blood AST activity and glucose, triglycerides and insulin concentration. The present study suggests that increasing the proportion of concentrates in the *pre-partum* diet may improve cows' energy status and reduce lipid mobilization around parturition.

Key words: metabolic status, periparturient, aspartate aminotransferase, non-esterified fatty acids, insulin, glucagons.

ŠĖRIMO PRIEŠ VERŠIAVIMĄSI ĮTAKA MEDŽIAGŲ APYKAITOS BŪKLEI ESTIJOS HOLŠTEINO VEISLĖS KARVIŲ ORGANIZME

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Santrauka. Pagerėjęs sausųjų medžiagų pasisavinimas šeriant karves racionu su didesniu energijos kiekiu prieš veršiavimąsi padeda išvengti susikaupusių riebalų pertekliaus. Tačiau šėrimas pašarais su dideliu energijos kiekiu ilgesnį laikotarpį gali daryti neigiamą poveikį veršiavimosi metu: gali sumažėti karvių apetitas, blogiau pasisavinti pašarai, intensyviau mobilizuotis riebalai. Tyrimo tikslas buvo nustatyti šėrimo prieš veršiavimąsi įtaką medžiagų apykaitos būklei po veršiavimosi Estijos Holšteino veislės karvių organizme. Dvi savaites prieš veršiavimąsi (s2, s1) skirtingu koncentrato kiekiu buvo šeriamas aukšto (A) ir žemo (Ž) produktyvumo karvių grupės, tuo tarpu tokiu pat kito koncentrato kiekiu buvo šeriamos pirmąsias keturias savaites po veršiavimosi (s1, s2, s3, s4). Siloso buvo duodama *ad libitum* viso eksperimento metu. Kraujo mėginiai, paimti iš stuburgalio venos s2, s1, s1, s2, s3 ir s4 savaičių metu, buvo tiriami norint nustatyti aspartataminotransferazės (AST) aktyvumą šlapale, gliukozės, ketoninių kūnų, trigliceridų, neesterifikuotų riebiųjų rūgščių (NERR), bendro cholesterolio, insulino ir gliukagono koncentracijas. Taip pat buvo atlikti pakartotiniai tyrimai taikant linijinę modelio analizę SAS sistema su mišria procedūra šėrimo prieš veršiavimąsi įtakai kraujo metabolitams nustatyti. Didesnė šlapalo koncentracija karvių kraujyje nustatyta A grupėje s1 (p=0,06) ir s2 (p=0,06) metu; didesnė NERR koncentracija nustatyta Ž grupėje s2 (p=0,01) ir s3 (p=0,02), taip pat s1 (p=0,08) ir s2 (p=0,08) metu; didesnė ketoninių kūnų koncentracija rasta Ž grupės karvių kraujyje s1 metu (p=0,0001), gliukagono koncentracija taip pat buvo didesnė Ž grupės karvių kraujyje s1 (p=0,03) ir s2 (p=0,02) bei s1 (p=0,08) ir s4 (p=0,06). Patikimų skirtumų nerasta atskirose grupėse tiriant aspartataminotransferazės aktyvumą karvių kraujyje, taip pat gliukozės, trigliceridų ir insulino koncentraciją. Atlikti tyrimai leidžia daryti išvadą, kad padidėjęs koncentratų kiekis racione prieš veršiavimąsi gali teigiamai veikti karvių energinę būklę ir sumažinti lipidų kaupimąsi šiuo laikotarpiu.

Raktažodžiai: medžiagų apykaitos būklė, veršiavimasis, aspartataminotransferazė, neesterifikuotos riebiosios rūgštys, insulinas, gliukagonas.

Introduction. To support foetal growth and delivery and to initiate and contribute to lactation a set of metabolic adjustments take place in the cows in late pregnancy and early lactation.

Due to reduced intake – up to 35% during last week of gestation (Grummer, 1995) – a discrepancy between the energy ingested and that required occurs, and negative energy balance develops *pre-partum*. Although *post-partum* intake gradually increases, the increase lags behind the increase in milk production and a negative energy balance is common this time.

To compensate for energy and nutrient deficiency fatty acids are released from adipose tissue and oxidized in hepatocytes that lead to raised blood NEFA and ketone bodies' concentration along with reduced glucose concentration. At the same time gluconeogenesis in the liver increases to ensure adequate glucose concentration in the blood as uterine uptake of glucose in the late-pregnant cow may account for 46% of maternal supply, while mammary uptake four days after calving may exceed it by 2.7 times (Bell, 1995).

A general conclusion of numerous studies is that prepartum feeding influences the metabolic status of the periparturient cow. Several investigations report that increasing DMI or using more energy-dense diets prior to parturition may prevent excessive lipid mobilization around parturition (Doepel et al., 2002; Vandehaar et al., 1999). On the other hand feeding energy-dense diets for a prolonged time *pre-partum* may lead to overconditioning at parturition followed by depressed appetite, reduced intake and more extensive lipid mobilization along with prolonged negative energy balance compared to cows fed restricted diets (Rukkwamsuk et al., 2000, 1999a,b,c, 1998). Excessive lipid degradation in turn may cause triglyceride accumulation in the liver and reduced gluconeogenic capacity of hepatocytes, that in turn predisposes cow to *post-partum* metabolic diseases (Bobe et al., 2004; Rukkwamsuk et al., 1999b; Vandehaar et al., 1999; Cadórniga-Valiño et al., 1997).

The aim of the present study was to discover metabolic responses of cows fed different amount of concentrates *pre-partum*.

Material and Methods

Animals, feeding and experimental design

On the experimental farm of the Estonian University of Life Sciences eight 2nd to 4th parity Estonian Holstein cows kept indoors in a tie-stall barn and milked twice a day were divided into two four-cow feeding groups: High (H) and Low (L).

The feeds used were: clover-timothy silage (1:1), concentrates (Concentrate 1 (C1): barley-oatmeal; Concentrate 2 (C2): 59.5% barley meal + 39.5% rape cake + 1% minerals) and mineral supplement. Cows were switched to the specified diets one week before the experimental period. Throughout two *pre-partum* and four *post-partum* experimental weeks (w-2, w-1, w1, w2, w3 and w4), silage was available *ad libitum* in both groups.

Pre-partum group L was fed 1 kg C1 + 50 g mineral supplement, group H 5 kg C1 + 50 g mineral supplement per day. *Post-partum* all cows were fed 5 kg C2 per day during the first five days, thereafter the amount was increased by 1 kg to the 10th day being 10 kg from the 10th day onwards. Concentrates were offered in two equal portions during morning and afternoon feed. To calculate daily intake all feeds and residues were weighed.

On calving day Ca-gluconate was subcutaneously injected to the cows. From the 13th to the 17th *post-partum* day cows were orally drenched with 320 g propylene glycol per day to reduce the risk of ketosis.

Sampling and analyses

Collection and analyzing of feed and milk samples are described in detail previously (Jaakson et al., ****).

Blood samples were obtained from the coccygeal vein on w-2, w-1, w1, w2, w3 and w4. Blood metabolites, enzymes and hormones were determined in heparinized plasma, glucagon in EDTA-plasma. Plasma was separated by centrifugation immediately after sampling and kept frozen at -20°C until the analyses. The activity of aspartate aminotransferase (AST) and the concentrations of metabolites (urea, glucose – GLC, ketone bodies – KB, triglycerides – TG, non-esterified fatty acids – NEFA, total cholesterol – CHOL) were measured spectrophotometrically: KB according to Trubka (1974); AST and urea using an enzymatic-UV-kinetic method (*Human Gesellschaft für Biochemica und Diagonostica GmbH* test kits); GLC, TG, NEFA and CHOL by enzymatic-colorimetric end-point method (*Human Gesellschaft für Biochemica und Diagonostica GmbH*- or *Roche* test kits for NEFA); insulin and glucagon using ^{125}I radioimmunoassay (*Diagnostic Products Corporation* test kits; *Coat-A-Count Insulin, Double Antibody Glucagon*).

Calculations

Using daily intake records and average crude protein (CP) content of feeds cows' CP intake was calculated. Using daily data (excluding data of 1st post-partum day) means per day were calculated on a weekly basis. Dry matter intake (DMI), energy corrected milk (ECM) production, milk constituents' yields and energy balance (EB) were calculated as described previously (Jaakson et al., ****).

Statistical analysis

The repeated measures general linear model analyses with SAS system's MIXED procedure were performed to discover the influence of *pre-partum* feeding on measured and calculated traits. For positively skewed traits data was logarithmically transformed. The following model $y_{ijke} = \mu + f_i + t_j + ft_{ij} + c_k + \varepsilon_{ijke}$ considering the influence of *pre-partum* feeding (treatment) – H or L (f_i), fixed time – w-2, w-1, w1, w2, w3, w4 (t_j), feeding x time interaction (ft_{ij}), random cow effect (c_k) and residual error (ε_{ijke}) were used. If $P<0.3$ the influence of parity and production of previous lactation as additional factors were included in the model.

The values given hereinafter are least squares means. Significance has been declared at $P \leq 0.05$, a tendency at $P \leq 0.10$.

Results

Intake, production characteristics and energy balance

DMI (kg/100 kg BW/d) and CP intake (kg/100 kg BW/d; data not shown) was higher in group H throughout

the trial except w1. ECM yield (kg/100 kg BW/d) did not differ significantly between the groups; milk protein+fat+lactose yield (g/100 kg BW/d) was higher in group H on w3 and w4, and EB differed significantly only pre-partum, being more positive in group H. Corresponding data are presented in Figure 1; more detailed discussion of intake and production characteristics and EB in groups L and H are given previously (Jaakson et al., xxxx).

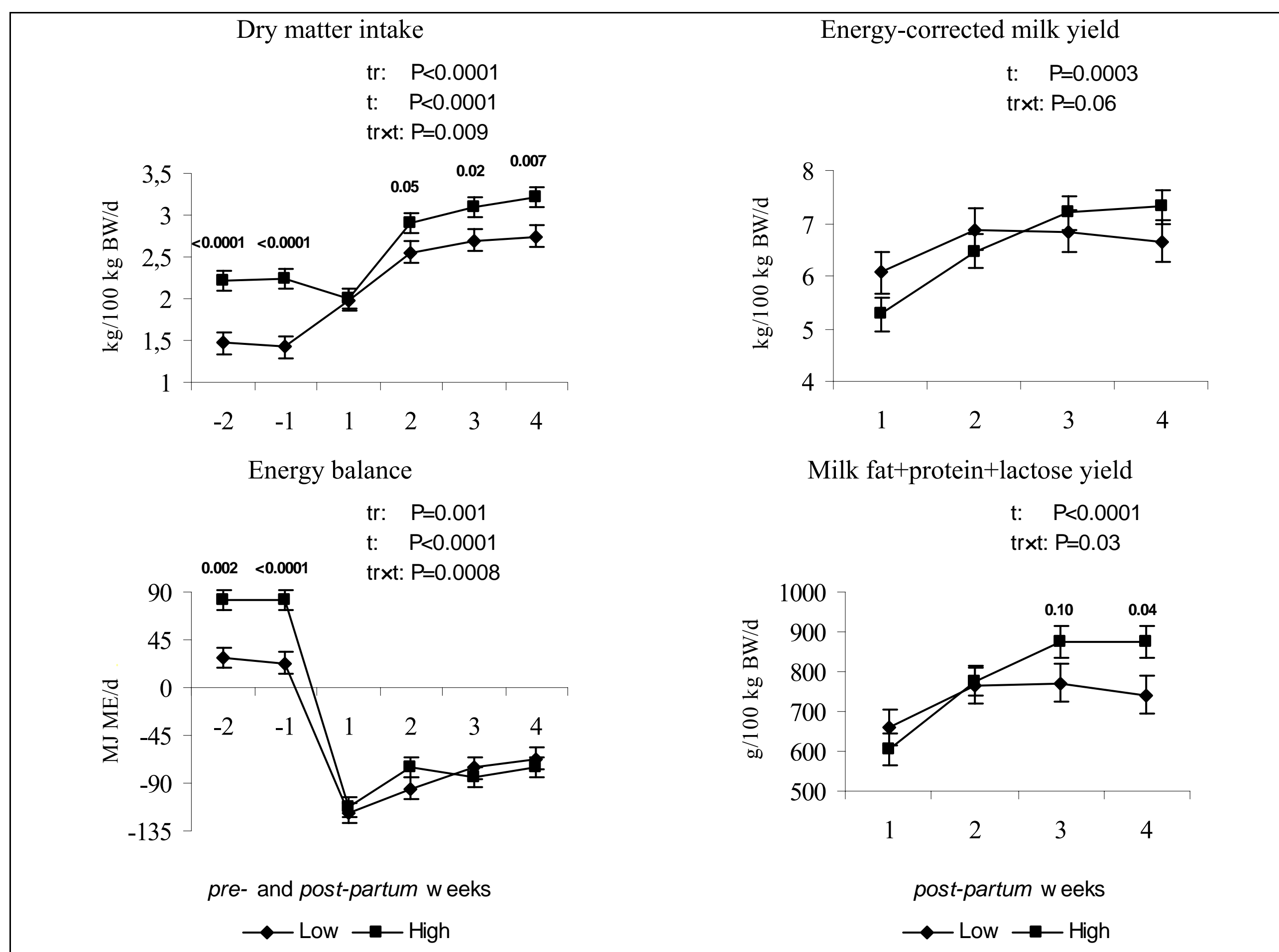

Figure 1. **Dry matter intake, energy balance, energy corrected milk- and milk protein+fat+lactose yield in groups Low and High. If P≤0.1, the influences of fixed effects** (tr: treatment, t: time, tr×t: treatment-time interaction) **are given on the top of figure and differences between the groups least squares means (LSM) above the lines. Error bars indicate pooled standard errors of LSM.**

Blood metabolites

Dynamics of blood metabolite concentration in groups L and H and groups' differences are presented in Figure 2.

Treatment was a factor affecting blood urea, glucagon, KB and NEFA concentrations, time period had an influence on most of the investigated metabolites, except urea and GLC. Treatment x time period interaction influenced KB content.

Blood AST activity did not differ significantly between the groups. In both groups activity had the lowest values *pre-partum*, then increased to peak on w1 in group H (P=0.0005) and on w2 in group L (P=0.01) followed by a decrease from peak to w4 (P=0.09 and P=0.009 in groups L and H respectively).

Blood urea concentration tended to be higher in group H on w-1 and w2. There was a numerical decrease in urea concentration in group H from w-2 to w1 (P=0.14), increase from the w1 nadir to the w2 peak (P=0.01) and subsequent decrease to w4 (p=0.01), while changes in group L were not statistically significant throughout the experiment.

GLC concentration tended to differ between the groups only on w4 being higher in group L. There were no significant changes in GLC concentration in group H throughout the trial, while in group L it decreased from w-2 to the w1 nadir (P=0.02) and a subsequent increase to w4 (P=0.02) occurred.

Blood ketone bodies' concentration was higher in group L on w1. There was a considerable rise in group L from w-1 to the peak on w1 (P=0.001) and following stabilization (P=0.01) on w2. In group H ketone bodies' concentration rose from w2 to its highest level on w3 (P=0.05) and then decreased (P=0.02) again.

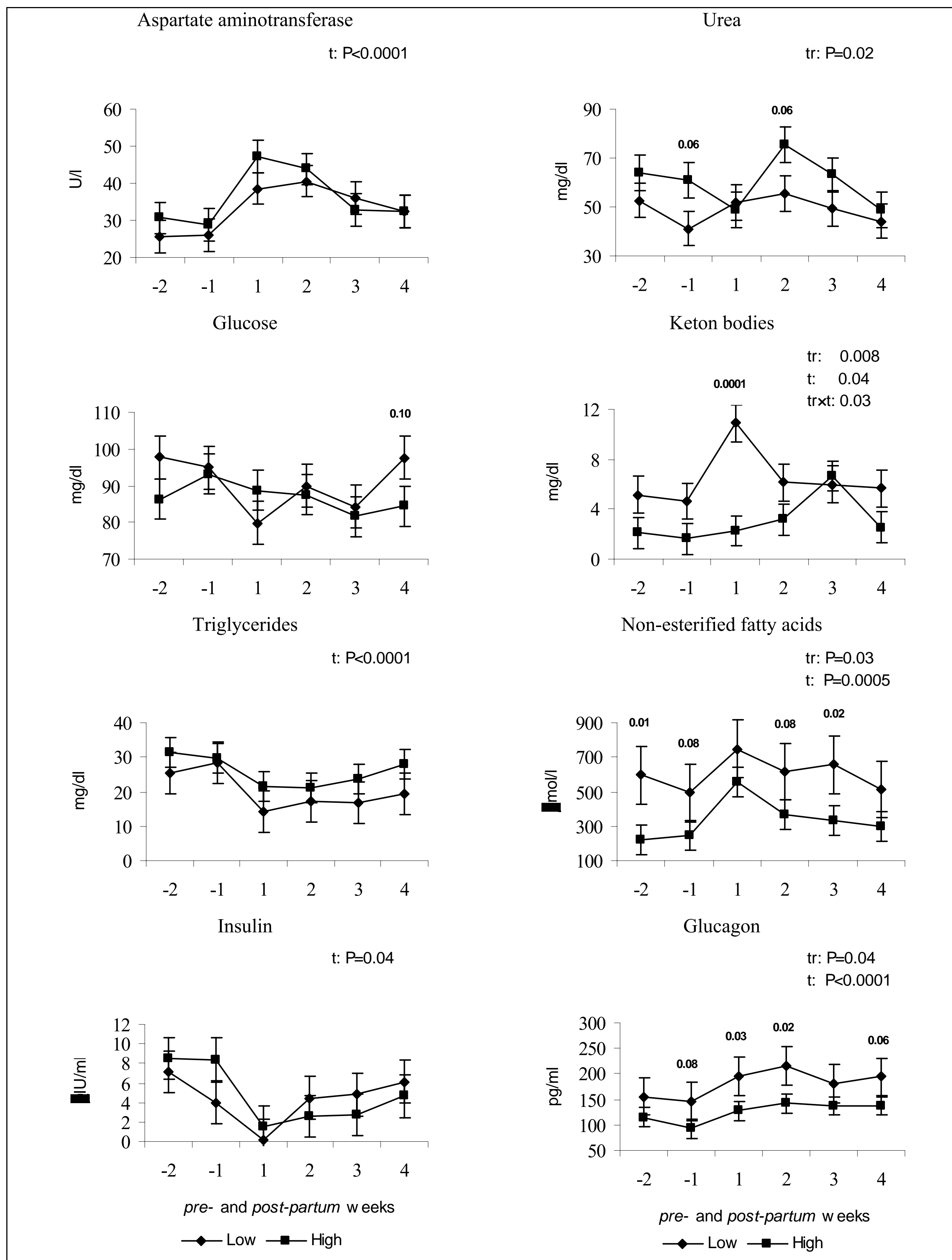

Figure 2. **Dynamics of blood metabolites concentration in groups Low and High. If P≤0.1, the influences of fixed effects** (tr: treatment, t: time, tr×t: treatment-time interaction) **are given on the top of figure and differences between the groups least squares means (LSM) above the lines. Error bars indicate pooled standard errors of LSM**

NEFA concentration was higher in group L on w-2 and w3 and tended to be higher on w-1 and w2. In both groups concentration increased from w-1 to a w1 peak (P=0.005 and P=0.0007 in groups L and H respectively) followed by a decrease to w4 (P=0.009 and P=0.004 in groups L and H respectively).

Blood TG concentration did not differ significantly between the groups. Compared to NEFA the curves of TG concentration had opposite shape; there was a decrease from pre-partum level to the w1 nadir in both groups (P<0.0001 and P=0.0008 in groups L and H respectively) and a subsequent increase from w1 to w4 (P=0.02 and P=0.006 in groups L and H respectively).

Insulin concentration in blood did not differ significantly between the groups. There was a decline from the w-2 peak to the w1 nadir in both groups (P=0.03 and P=0.02 in groups H and L respectively), while *post-partum* changes were not significant.

Blood glucagon concentration was higher in group H on w1 and w2 and tended to be higher on w-1 and w4. Concentration was lowest *pre-partum* followed by an increase from w-1 to the highest level on w2 in both groups (P<0.0001 and P=0.001 in groups L and H respectively). No significant changes occurred from w2 onwards.

Discussion

Pre-partum metabolic status

Blood AST activity and urea concentration were used as markers of protein absorption and metabolism. Limited data has been published on the influence of *pre-partum* feeding on blood AST activity. Roche et al. (2005) reported no effect of pre-partum intake differences on AST activity. In this experiment slightly higher AST activity in group H *pre-partum* was observed; however, differences between the groups were not statistically significant (Figure 2). Similarly Dann et al. (2006) and Park et al. (2002) measured higher AST activity in cows with higher crude protein consuming *pre-partum*. Therefore we suggest that higher blood AST activity in group H *pre-partum* might be response to higher protein intake compared to group L.

As reported previously, blood urea concentration, similarly to AST activity, increases with consumed protein level in the ration (Putnam and Varga, 1998; Greenfield et al., 2000; Moorby et al., 2000; Doepel et al., 2002). In our study blood urea concentration was numerically higher in group H on w-2 and tended to be higher on w-1 (P=0.06); in addition, there was a small positive correlation between blood urea concentration and crude protein intake (r^2=0.23); therefore we suggest that in the present study higher blood urea concentration *pre-partum* might be a reflection of higher crude protein intake. In this experiment blood urea concentration in group H declined from w-2 to parturition while in group L there were no significant changes *pre-partum*; however, the lowest concentration in group L occurred on w-1. Greenfield et al. (2000) observed decline of blood urea concentration prior to calving in cows consuming differing amounts of protein. According to Greenfield et al. (2000) a decrease in urea concentration prior to parturition may indicate more efficient use of amino acids for protein synthesis, decreased protein intake, or both. As Bell (1995) reviewed, in cows prior to parturition hepatic protein synthesis increases and amino acid catabolism decreases despite unchanged or decreased protein intake. In our experiment CP intake *pre-partum* was unchanged in both groups (data not shown); therefore, a decline in urea concentration may indicate increased hepatic protein synthesis; at the same time enhanced urea recycling to the rumen may also play a role.

Blood NEFA and KB concentrations have been used to evaluate cows' energy status in numerous studies (Dann et al., 2006; Douglas et al., 2006; Roche et al., 2005; Holtenius et al, 2003; McNamara et al., 2003; Doepel et al, 2002; Ryan et al., 2003; Grum et al., 1996); rarely blood TG has been used. In our experiment cows in group L had about 12% lower (ns.) blood TG concentration and higher blood NEFA concentration *pre-partum*; in addition, cows in group L had numerically higher blood KB level (P=0.13 and P=0.14 on w-2 and w-1 respectively). This reflects lower DMI and poor EB and indicates more intensive lipomobilization and ketogenesis in group L, in accord with the data of analogous studies (Dann et al., 2006; Douglas et al., 2006; Roche et al., 2005; Doepel et al, 2002; Vandehaar et al., 1999; Olsson et al., 1998).

Blood GLC has been reported to vary largely being therefore not sensitive enough to assess energy status (McNamara et al., 2003; Herdt, 2000). Indeed, it is difficult to interpret CLC dynamics in our treatment groups; we also found neither effect of treatment and time nor their interaction on blood GLC concentration; however, there is evidence that cows with higher *pre-partum* DMI, or fed diets with improved energy density had higher blood GLC concentration along with more positive EB and moderate lipomobilization (Douglas et al., 2006; Roche et al., 2005; Patton et al., 2004; Holtenius et al, 2003).

Insulin and glucagon are the main hormones controlling the level of blood glucose, regulating intensity of gluconeogenesis and adjusting balance between lipogenesis and lipomobilization as well as between protein synthesis and breakdown (Hippen et al., 1999; She et al., 1999). Blood insulin concentration has been shown to increase with dietary level of energy and/or protein (Douglas et al., 2006; Roche et al., 2005; Patton et al., 2004; Holtenius et al., 2003; Doepel et al., 2002; Moorby et al., 2000; Grum et al., 1996); glucagon responded with an opposite effect (Smith et al., 1997) or showed no treatment effect (Patton et al., 2004). In our experiment *pre-partum* blood insulin concentration was not significantly higher, but glucagon concentration tended to be lower on w-1 in cows from group H, characterized with higher DMI and, consequently, with improved supply of glucose, propionate and glycogenic amino acids, and with a moderate rate of lipomobilization compared to group L.

Post-partum metabolic status

AST activity in blood peaked on w1 in group H and on w2 in group L and then decreased again. Similar dynamics have been reported previously: Park et al. (2002) and Hoedemaker et al. (2004) refer that post-partum increase of AST activity is associated with extensive muscle

breakdown and increased amino acid catabolism; Bobe et al. (2004) and Xu et al. (1998), in addition, point to a relationship between elevated AST activity and *post-partum* NEFA accumulation into liver. In this experiment blood AST activity and NEFA concentration remained within the normal range (Kaneko et al., 1997); therefore we suggest that the *post-partum* rise in AST activity was the result of skeletal muscle breakdown and increased catabolism of amino acids rather than the consequence of liver damage.

Post-partum blood AST activity did not differ significantly between the groups, therefore it is difficult to interpret the results; however, activity was numerically higher in group H on w1 (P=0.14) that accords with the data reported by Dann et al. (2005): blood AST activity on 1…4 days *post-partum* was higher in cows fed *pre-partum ad libitum* compared to those fed restricted diets. Presuming that raised AST activity *post-partum* indicates degradation of tissue protein, higher AST activity would be expected in group L, at least on w2, when DMI in this group was lower (Figure 1) and crude protein intake tended to be lower compared to group H (P=0.07, data not shown). Indeed, Park et al. (2002) investigated cows with different *pre-partum* crude protein consumption: *post-partum* blood AST activity tended to decrease with protein level fed *pre-partum*.

Post-partum blood urea concentration tended to be higher in group H on w2 (P=0.06); the difference being the result of a prior rise from w1 nadir to w2 peak, followed by a subsequent decrease from w2 onwards; at the same time in group L urea concentration remained quite stable throughout the *post-partum* period. As reported previously, raised plasma urea concentration reflects tissue protein degradation and/or excess protein consumption (Doepel et al., 2002; Park et al., 2002; Huyler et al., 1999). We suggest that in the present study higher blood urea concentration in group H on w2 might reflect higher dry matter intake along with excess crude protein consuming at this time; the fact that ECM- and milk protein yield in w2 was comparable in the groups (6.88 kg/100 kg BW/d vs. 6.46 kg/100 kg BW/d for ECM; 210,7 g/100 kg BW/d vs. 208,3 g/100 kg BW/d for milk protein yield in groups L and H respectively), while EB was slightly more positive in group H (-95.02 MJ ME/d vs. -74.83 MJ ME/d in groups L and H respectively; P=0.13; Figure) may support this. From w2 onwards in group H, despite still higher crude protein intake, blood urea concentration decreased and significant differences between the groups disappeared; as milk protein yield in group H showed clear increase, that led to numerically higher milk protein yield in this group on w4 (P=0.13), decrease in urea concentration in group H might be related to more efficient usage of absorbed amino acids for milk protein synthesis.

Rise of NEFA concentration at parturition and/or during first week of lactation is typical in dairy cows (Patton et al., 2004; Holtenius et al., 2003; Doepel et al., 2002; Vazquez-Añon et al., 1994) reflecting intensified mobilization of stored lipids in conjunction with a drop in intake and onset of milk production (Doepel et al., 2002; Grummer, 1995; Vazquez-Anon et al., 1994). In this experiment blood NEFA had a peak concentration on w1 followed by a steady decrease in both groups. The peak was numerically higher (ns.) in group L; differences between the groups occurred only on w2 (P=0.08) and w3 (P=0.02). TG concentration in blood responded oppositely to NEFA: lowest values occurred after calving – on w1 in group L and on w2 in group H – followed by a steady increase in both groups. Although differences between the groups were not significant, in average, blood TG concentration *post-partum* was about 29% lower in group L that together with higher NEFA level indicate to more extensive lipomobilization in this group. In addition, blood ketone bodies, product of incomplete oxidation of NEFA, were elevated on w1 in group L, exceeding significantly the group H' average (P=0.0001); on w2 and w4 only numerical differences (P≤0.14) appeared. Blood glucose concentration did not differ significantly between the groups; however, the lowest average amongst investigated time periods occurred in group L on w1.

Several experiments have been conducted to relate *pre-partum* feeding regimen with *post-partum* metabolic parameters; often blood glucose, NEFA and ketone bodies have been used to characterize cows' carbohydrate and lipid status. Contrarily to our results, *post-partum* concentration of blood NEFA has been found to be higher and also duration of the *post-partum* period raised NEFA was prolonged in cows force-fed for a longer period *pre-partum* (Dougles et al., 2006; Holtenius et al., 2003). Douglas et al. (2006), in addition, reported higher *post-partum* blood ketone bodies' concentration in long-term force-fed cows; at the same time blood glucose level did not differ between the force-fed and restricted groups. Force-fed cows in these experiments had higher BCS at parturition that was associated with a more pronounced drop in intake at parturition and depressed appetite *post-partum*, therefore mobilizing adipose tissue more extensively compared to restricted-fed cows. Improving DMI or increasing the ration's energy density for several weeks *pre-partum* has reduced blood NEFA concentration *post-partum* in several experiments (Patton et al., 2004; Doepel et al., 2002; Dann et al., 1999; Vandehaar et al., 1999; Olsson et al., 1998). Blood glucose and ketone bodies appeared to be not sensitive enough to respond differences in feeding regimen by Roche et al. (2005) and Moorby et al. (2000). As we found, Patton et al. (2004) observed *post-partum* reduction in blood ketone bodies concentration along with reduced blood NEFA level in cows consuming more feed *pre-partum*; in addition these cows had higher blood glucose levels. On the basis of our results we suggest that reduced *post-partum* lipomobilization in group H could be the consequence of higher pre-partum intake of a concentrate-rich diet. Although in the present study we did not measure ruminal characteristics, there is evidence that *pre-partum* feeding intensity is related to rumen papilla growth that facilitates absorption of VFA and other substrates (Rabelo et al., 2003; Harmon et al., 1991). In addition, as Overton and Waldron (2004) concluded, a concentrate-rich diet should promote ruminal microbial adaptation to diets typically fed during lactation, and provide increased amounts of propionate to spare glu-

cose, support gluconeogenesis and reduce lipomobilization.

Amongst investigated hormones *post-partum* blood insulin concentration did not differ between the groups; however, compared to the *pre-partum* experimental period, *post-partum* insulin concentration was reduced in both groups, which is typical in dairy cows (Doepel et al., 2002; Moorby et al., 2000; Dann et al., 1999); moreover, on w1 it was close to zero in group L. At the same time *post-partum* blood glucagon concentration in group L exceeded group H' averages in any time point that together with data of blood NEFA, TG and ketone bodies indicated more pronounced mobilization of depot fat in this group.

Conclusions

Our results indicate that increasing the amount of concentrates in *pre-partum* diet may improve cows' *post-partum* metabolic status. Cows fed a higher proportion of concentrates *pre-partum* had more efficient usage of absorbed amino acids and less pronounced lipomobilization.

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