INFLUENCE OF *PRE-PARTUM* FEEDING ON *POST-PARTUM* INTAKE, PRODUCTION AND ENERGY BALANCE IN ESTONIAN HOLSTEIN COWS

Hanno Jaakson*, Katri Ling, Helgi Kaldmäe, Jaak Samarütel, Tanel Kaart, Olav Kärt
Institute of Veterinary Medicine and Animal Sciences, Estonian University of Life Sciences, 46 Kreutzwaldi St, 51006 Tartu, Estonia
** Corresponding author, tel. +372 7 31 3474; fax. +372 7 31 3477; e-mail: hanno.jaakson@emu.ee*

Summary. The aim of the study was to examine effects of *pre-partum* feeding on *post-partum* intake, production and energy balance in cows. Two weeks *pre-partum* (w-2, w-1) different amounts of one concentrate was fed to group Low (L) and High (H) 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 experimental period. Dry matter intake was higher in group H ($P \leq 0.05$) except for w1. Energy corrected milk (ECM) yield did not differ between groups; however, in contrast to group L there was a clear increase in ECM yield from w1 to w4 in group H ($P<0.0001$). Milk fat yield tended to be higher in group H on w3 ($P=0.06$) and was higher on w4 ($P=0.05$), milk lactose yield was higher in group H on w4 ($P=0.04$); protein yield did not differ between the groups. Energy balance was more positive in group H *pre-partum* ($P<0.0001$) and did not differ *post-partum*. Obtained results indicate that increasing feeding level *pre-partum* could improve *post-partum* intake and production performance at the same time having little influence on energy balance.
Key words: dry matter intake, energy corrected milk, milk fat yield, milk lactose yield, milk protein yield.

ŠĖRIMO PRIEŠ VERŠIAVIMĄSI ĮTAKA PAŠARO PASISAVINIMUI, PRODUKTYVUMUI IR ENERGIJOS BALANSUI PO VERŠIAVIMOSI ESTIJOS HOLŠTEINO VEISLĖS KARVIŲ ORGANIZME

Hanno Jaakson*, Katri Ling, Helgi Kaldmäe, Jaak Samarütel, Tanel Kaart, Olav Kärt
Veterinarinės medicinos ir gyvulininkystės institutas, Estijos gyvulininkystės universitetas, Kreutzwaldi 46, 51006 Tartu, Estija
** Bendraautorius, tel. +372 731 3474; faks. +372 731 3477; el. paštas: hanno.jaakson@emu.ee*

Santrauka. Tyrimo tikslas buvo nustatyti šėrimo prieš veršiavimąsi įtaką pašaro pasisavinimui, produktyvumui ir energijos balansui po veršiavimosi karvių organizme. Dvi savaites prieš veršiavimąsi (s2, s1) skirtingu to paties koncentrato kiekiu buvo šeriamos žemo (Ž) ir aukšto (A) produktyvumo karvės, tuo tarpu pirmąsias keturias savaites po veršiavimosi visos karvės gavo tokį pat kito koncentrato kiekį (s1, s2, s3, s4). Silosu karvės buvo šeriamos *ad libitum* viso eksperimento metu. Geriau sausąsias medžiagas pasisavino A grupės galvijai ($p \leq 0,05$), išskyrus s1. Energiškai pakoreguoto pieno (EKP) produkcija tarp karvių grupių nesiskyrė, tačiau, priešingai nei Ž grupėje, pastebėta EKP produkcijos padidėjimas nuo s1 iki s4 A grupėje ($p<0,0001$). Didesnis pieno riebalų kiekis taip pat nustatytas A grupėje s3 ($p=0,06$) metu ir s4 ($p=0,05$) metu, didesnė pieno laktozės gamyba taip pat buvo A grupėje s4 ($p=0,04$); baltymų kiekis tarp grupių nesiskyrė. Labiau teigiamas energijos balansas buvo A karvių grupėje prieš veršiavimąsi ($p<0,0001$), jis nepasikeitė ir po karvių veršiavimosi. Tyrimo rezultatai leidžia teigti, kad geriau šeriant prieš veršiavimąsi pašaras geriau pasisavinamas, ir karvės produktyvesnės po veršiavimosi, tačiau pašaro įtaka energijos balansui nežymi.
Raktažodžiai: sausosios medžiagos pasisavinimas, energiškai koreguotas pienas, pieno riebalų gamyba, pieno laktozės gamyba, pieno baltymų gamyba.

Introduction. In dairy cows' late pregnancy and early lactation discrepancy between the amount of energy required and ingested leads to negative energy balance (NEB) and intensive use of store lipids, making covering its energy requirements one of the most important problems in transition cow feeding.

Already 3 weeks *pre-partum*, being influenced by the complex of nutritional and metabolic factors (Ingvartsen & Andersen, 2000), feed intake of dairy cows may decrease up to 35% (Grummer, 1995). It has been suggested that using more energy-dense diets and increasing dry matter intake (DMI) prior to parturition may prevent excessive lipid mobilization around the parturition (Vandehaar et al., 1999; Doepel et al., 2002) and increase *post-partum* intake (Grummer, 1995; Doepel et al., 2002; McNamara et al., 2003a). Increased intake *post-partum* may lead to higher milk yield (Holcomb et al., 2001; McNamara et al., 2003a) or have no influence on performance (Vandehaar et al., 1999; Rabelo et al., 2003); at the same time improved intake has not always been related to improved energy status (McNamara et al., 2003b).

On the other hand prolonged feeding of energy-dense diets *pre-partum* may lead to overconditioning and depressed appetite at parturition followed by prolonged NEB, extensive degradation of store lipids and liver lipidosis (Rukkwamsuk et al., 1998; 1999a,b,c; 2000), however, not necessarily causing poor milk production (Rukkwamsuk et al., 1998; 1999a,b,c; 2000; Agenäs et al., 2003).

General feeding recommendation for dry cows is that intake during last weeks of gestation should be maximized; at the same time overfeeding during dry period that may lead to overconditioning and depressed appetite at parturition must be avoided (Drackley, 1999; Overton & Waldron, 2004).

The aim of present study was to investigate effects of *pre-partum* feeding level on *post-partum* intake, production performance and energy balance (EB) in Estonian Holstein.

Material and Methods

Animals, feeding and experimental design

On the experimental farm of Estonian University of Life Sciences eight 2nd to 4th parity Estonian Holstein cows kept indoors in tie stall barn and milked twice a day were randomly divided into two four-cow feeding groups: treatment High (H) and Low (L). Experimental diets were composed of clover-timothy silage, Concentrate 1 (barley-oatmeal) and Concentrate 2 (barley meal, rape cake and minerals). Exact ingredients content of feeds is given in Table 1.

Table 1. **Ingredients composition and chemical composition of feeds**

Feed	Clover-timothy silage	Concentrate 1	Concentrate 2
Ingredient			
Clover-timothy silage 1:1 (%)	100	-	-
Barley-oatmeal 1:1 (%)	-	100	-
Barley meal (%)	-	-	59.5
Rape cake (%)	-	-	39.5
Minerals (%)	-	-	1
Chemical composition			
Dry matter (g/kg)	241	884	891
Crude protein (g/kg DM)	168	138	223
Crude ash (g/kg DM)	98	30	54
Crude fibre (g/kg DM)	250	100	83
Crude fat (g/kg DM)	43	38	62
N-free extractives (g/kg DM)	441	694	578
Ca (g/kg DM)	13.5	0.9	5.6
P (g/kg DM)	2.7	4.0	7.6
ME (MJ/kg DM)	9.5	12.1	13.1
MP (g/kg DM)	76.5	98.9	113.3

Cows were switched to the diets one week before the start of 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 and group H 5 kg Concentrate 1 per day; in both groups 50 g mineral supplement was offered in mixture with concentrates. *Post-partum* all cows were fed 5 kg Concentrate 2 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 feedings. To calculate daily intake all feeds and residues were weighed.

To avoid parturient paresis Ca-glyconate was subcutaneously injected to cows on the day of calving. 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. Cows were clinically healthy throughout the experimental period.

Sampling and analyses

Equal daily portions of feed samples were pooled on weekly basis. Pooled samples were analyzed according to AOAC (1990) recommendation for dry matter (2 hours drying at 130°C), crude ash (6 hours combustion at 550°C), crude protein (*Kjeltec Auto 1030*), crude fibre (*Fibertec*) and crude fat (*Soxtec System 1040, Extraction Unit*) content.Based on these analyses experimental period averages were calculated; nutritional value of feeds was evaluated using these averages (Table 1).

Cows were weighed and body condition was scored according to Edmondson et al. (1989) on w-2 and on w4.

Daily milk yield was recorded and milk samples were collected (from 1st to 5th post-partum day separately at morning and afternoon milking, thereinafter every second day pooling morning and afternoon samples) and analyzed for fat, protein and lactose content (*System 4000*; colostrum's protein content: *Kjeltec Auto 1030*).

Calculations

Using daily intake records and average dry matter content of feeds (Table 1) and propylene glycol (80%, 22.8 MJ/kg) daily DMI of silage (DMI_S) and concentrates (DMI_C) as well as total DMI (DMI_T) were calculated. Energy corrected milk (ECM) was calculated (from 1st to 5th post-partum day: at first separately for morning and afternoon samples, then average of the day; thereafter for every second day in pooled samples) according to Saunja et al. (1991) as:

ECM (kg) = Milk yield (kg/d) x ((0.383 x Fat% + 0.242 x Protein% + 0.1654 x Lactose% ++ 0.207) / 3.140).

Table 2. **Effect of different amount of concentrates *pre- partum* on intake and production characteristics, BW, BCS and EB in periparturient cows (Least square means values)**

Parameter	Week	Treatment groups				Difference between the groups (P)	Influence of fixed effects (P)		
		Low		High			Treatment	Time	Treament× Time
		LSM	Pooled SEM	LSM	Pooled SEM				
DMI_s (kg/100 kg BW/d)	-2	1.634	0.069	1.682	0.065	0.30	0.009	0.008	0.62
	-1	1.578		1.668		0.10			
	1	1.615		1.763		0.98			
	2	1.681		1.802		0.29			
	3	1.707		1.886		0.03			
	4	1.742		1.896		0.06			
DMI_c (kg/100 kg BW/d)	-2	0.120	0.061	0.673	0.061	<0.0001	0.0006	<0.0001	<0.0001
	-1	0.122		0.684		<0.0001			
	1	0.689		0.780		0.65			
	2	1.191		1.345		0.20			
	3	1.252		1.415		0.14			
	4	1.283		1.468		0.03			
DMI (kg/100 kg BW/d)	-2	1.47	0.13	2.22	0.12	<0.0001	<0,0001	<0,0001	0.009
	-1	1.42		2.23		<0.0001			
	1	1.98		2.00		0.90			
	2	2.56		2.90		0.05			
	3	2.69		3.09		0.02			
	4	2.74		3.22		0.007			
ECM (kg/100 kg BW/d)	1	6.06	0.39	5.28	0.32	0.12	0.89	0.0003	0.06
	2	6.88		6.46		0.40			
	3	6.84		7.21		0.47			
	4	6.65		7.31		0.19			
Milk fat yield (g/100 kg BW/d)	1	220.5	20.7	223.3	20.7	0.91	0.09	0.008	0.24
	2	258.3		259.2		0.97			
	3	262.3		315.8		0.06			
	4	240.0		294.7		0.05			
Milk protein yield (g/100 kg BW/d)	1	222.7	12.5	194.9	10.5	0.11	0.74	0.98	0.05
	2	208.3		210.7		0.88			
	3	198.3		214.0		0.35			
	4	193.9		219.6		0.13			
Milk lactose yield (g/100 kg BW/d)	1	204.7	19.8	185.4	19.8	0.50	0.26	<0.0001	0.03
	2	286.1		304.0		0.53			
	3	298.2		343.6		0.12			
	4	295.1		358.8		0.04			
EB (MJ ME/d)	-2	28.28	9.94	83.14	9.24	0.0002	0.001	<0.0001	0.0008
	-1	23.36		82.21		<0.0001			
	1	-117.80		-112.58		0.69			
	2	-95.02		-74.83		0.13			
	3	-75.90		-84.84		0.49			
	4	-66.76		-75.74		0.49			
BW (kg)	-2	759	29	696	38	0.10	0.13	<0.0001	0.91
	4	686		631		0.16			
BCS	-2	3.25	0.10	2.99	0.10	0.02	0.01	<0.0001	0.92
	4	2.82		2.55		0.02			

Based on daily milk yield and composition daily fat, protein and lactose yield were calculated.

Daily EB was calculated as the difference between energy consumed and energy required for maintenance and milk production according to the Estonian feeding recommendations (Oll, 1995). Daily weight loss found by dividing the overall weight loss into equal daily portions was taken into account to calculate BW used in equations:

$EB\ (MJ) = E_{consumed}\ (MJ) - E_{required}\ (MJ)$ where
$E_{required}\ (MJ) = E_{maintenance}\ (MJ) + E_{lactation}\ (MJ)$
$E_{maintenance} = 0.473 \times BW^{0.75}\ (kg)$

$E_{lactation}$ = ECM (kg) x 5.25 (± correction for milk yield lower or higher than 15 kg ECM).

Using daily data (excluding data of 1st post-partum day) averages per day were calculated on a weekly basis; for DMI_S, DMI_C, DMI_T, ECM and milk constituents yield averages were calculated per 100 kg BW (Table 2) and are used throughout the present paper.

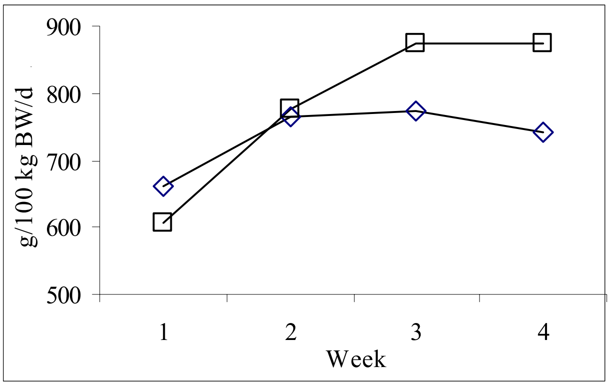

Figure 1. **Dynamics of milk constituents yield (fat+protein+lactose) in groups H (□) and L (◊). Differences between the groups least square means (LSM) are not significant on w1 and w2, LSM tend to differ on w3 (P=0.10) and differ significantly on w4 (P=0.04)**

Statistical analysis

The repeated measures general linear models analyses with SAS system's MIXED procedure were performed to find out the influence of *pre-partum* feeding on measured and calculated traits. For positively skewed traits the logarithm transformation was applied. The following model $y_{ijke} = \mu + f_i + t_j + ft_{ij} + c_k + \mu_{ijke}$ considering 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 to model.

The values given hereinafter are least square means. Significance has been declared at P≤0.05,a tendency at P≤0.1.

Results and Discussion

Feed intake

Treatment and time influenced all intake characteristics (P<0.01), treatment × time interaction affected DMI_C and DMI_T (P<0.01; Table 2).

Pre-partum DMI_T and DMI_C were higher (P<0.0001) in group H, DMI_S tended to be higher (P=0.1) in group H on w-1, (Table 2). Higher *pre-partum* DMI_T in group H achieved mainly on account of DMI_C indicates to possibility of increasing intake by feeding energy-rich diets and is consistent with results of Keady et al. (2001), Agenäs et al. (2003) and McNamara et al. (2003a). The impact of energy-rich diet accords with Rabelo's et al. (2003) finding that ruminal dry matter digestibility is higher with low fiber diets allowing faster rumen digesta evacuation resulting in higher DMI. Contrarily Olsson et al. (1998) found that *pre-partum* DMI decrease is less pronounced with high fiber diets. It is supposed that *pre-partum* reduction of intake might be partly related to mechanical compression of the rumen by the growing uterus (Ingvartsen et al., 1992); however, well maintained intake in experiment of S. Agenäs et al. (2003) and our results do not support that. It is more likely that intake is mainly regulated by nutritional, metabolic and hormonal signals (Ingvartsen & Andersen, 2000). Holtenius et al. (2003) and Liefers et al. (2003) point out the role of leptin and insulin in intake regulation.

Post-partum DMI_T was higher (P≤0.05) in group H starting from w2; DMI_S was higher (P=0.03) in group H on w3 and tended to be higher (P=0.06) on w4; DMI_C was higher (P=0.03) in group H on w4 (Table 2). In addition, cows in group H showed higher rate of intake increase: from w2 to the end of experiment increase of DMI_T, DMI_S, and DMI_C in group H was clearly expressed (P<0.01) while in group L only slight increase (ns.) occurred from w2 onwards.

Improved *post-partum* intake in group H might be effect of *pre-partum* concentrate-rich ration. It has been suggested that feeding intensity is related to rumen short chain fatty acid (SCFA) production, the last in turn stimulates rumen papilla growth and facilitates absorption (Harmon et al., 1991) that might positively influence group H's DMI_S and DMI_C in our experiment. On the other hand Ingvartsen et al. (2001) observed no difference between the *post-partum* DMI in cows fed concentrate-based versus roughage-based diets *pre-partum*. Similarly Agenäs et al. (2003) report comparable *post-partum* DMI in cows fed TMR of different energy density *pre-partum*. It has been shown that *pre-partum* concentration of rumen volatile fatty acids (VFA) is raised (Andersen et al., 1999) and flux of SCFA on the rumen epithelium higher (Sehested et al., 1997) in cows fed concentrate-based vs. roughage-based diet, however, no morphological-histological differences in rumen papilla growth and in *post-partum* DMI between the treatments have been observed (Sehested et al., 1997; Andersen et al., 1999). In our experiment we did not record rumen characteristics but it is reasonable to assume that more active rumen epithelium and more intensive absorption of cows in group H might be a reason for improved intake *post partum*.

Milk production

Treatment had effect on milk fat yield (tendency; P=0.09); time influenced ECM-, fat- and lactose yield (P<0.01); treatment × time interaction influenced ECM yield (tendency; P=0.06) and protein- and lactose yield (P≤0.05; Table 2).

ECM yield did not differ between the groups (Table 2); however, in contrast to group L, there was a clearly expressed increase (P<0.0001) in ECM yield in group H that might suggest to improved lactation performance in this group. Similarly to us Rabelo et al. (2003) observed more pronounced milk production increase in high-fed cows compared to controls. McNamara et al. (2003a) and Ryan et al. (2003) report the positive effect of increased dietary energy density *pre-partum* on early lactation milk and milk constituents yield, however, in addition to increased intake the effect was partly contributed by slightly more extensive lipid mobilisation in high-fed cows. In our experiment there were no notable differences between the groups in BW- and BCS-loss (73 kg vs. 65 kg for BW and 0.43 vs. 0.44 points for BCS in groups L and H respectively), therefore we can consider that improved lactation performance in group H was mainly the effect of *pre-partum* feeding. At the same time Doepel et al. (2002) report only insignificant if any effect of *pre-partum* feeding intensity on post-partum milk performance despite its beneficial effect on *post-partum* intake. Contrarily to us, Holcomb et al. (2001) conclude that *pre-partum* restricted feeding vs. free choice may have advantages for milk performance. On the basis of our results we can suppose that that H-cows in the present study were better adapted to successful lactation. *Pre-partum* energy-rich diet evidently facilitated rumen epithelium development and contributed to more intensive absorption of nutrients leading to improved intake, higher energy input and clearly expressed milk production increase in group H.

Milk protein yield did not differ significantly between the groups; milk fat and lactose yield did not differ on w1…w2. Milk fat yield tended to be higher (P=0.06) in group H on w3 and fat and lactose yield were higher ($P \leq 0.05$) in group H on w4 indicating to positive effect of *pre-partum* energy-dense diet on milk constituents' yield that became evident from w2 onwards (Fig. 1 and Table 2).

In different studies *pre-partum* energy-dense diet has increased (Keady et al., 2001; McNamara et al., 2003a; Ryan et al., 2003) or has not influenced milk fat yield (Dewhurst et al., 2000; Doepel et al., 2002; Rabelo et al., 2003). Although common opinion is that higher proportion of concentrates' intake leads to milk fat depression Dann et al. (1999) and Bargo et al. (2003; review) state that higher concentrates' intake decreases milk fat content but increases fat yield due to increase in milk production in the course of lactation.

Positive effect of *pre-partum* concentrate-rich diet on milk fat yield in group H can be explained by increase of DMI_T that increased energy and nutrients input necessary for fat synthesis. On the other hand higher DMI_C in group H was accompanied by higher DMI_S; latter might compensate fat-depressive effect of concentrates. The proportion of concentrates' intake was also below 50% of DMI_T referred to as threshold above that fat depression may occur (Ashes et al., 1997).

Milk protein yield on w1 was numerically higher (P=0.11) in group L. As colostrum's protein content may vary largely between the individual cows (Marnila & Korhonen, 2003), higher protein yield in group L on w1 was rather the reflection of unequally high protein content in colostrum of two cows during several post-partum days (data not shown) than the effect of pre-partum feeding regimen. At the same time in contrast to group L protein yield in group H from w1 to w4 increased (P=0.03) that led to numerically higher (P=0.13) protein yield on w4 indicating to positive effect of *pre-partum* energy-dense diet on milk protein yield reported also by Bargo et al. (2003, review), McNamara et al. (2003a) and Ryan et al. (2003). Opposing to that Dewhurst et al. (2000), Doepel et al. (2002) and Rabelo et al. (2003) observed no effect of *pre-partum* feeding level on milk protein yield. As Ryan et al. (2003) concluded, more intensive concentrates feeding *pre-partum* likely increases endogenous protein reserves available for milk protein synthesis; in our experiment protein reserves might be one of the contributors to clearly expressed milk protein yield increase in group H compared to group L. In addition, improved *post-partum* intake in group H evidently increases ruminally available starch that according to Hristov and Ropp (2003) enhances bacteria population and intensifies ammonia capture in the rumen contributing to higher protein yield. According to Korhonen et al. (2002) higher proportion of duodenal-absorbed amino acids play an important role to enhance milk protein yield; we may assume that in the present study improved *post-partum* intake in group H increased amount of duodenal-absorbed amino acids that in turn could play contributory role to milk protein synthesis.

In our study we observed higher milk lactose yield in group H on w3 (numerically higher; P=0.12) and on w4 (P=0.04). Similarly to us Dann et al. (1999) and Ryan et al. (2003) report higher milk lactose yield associated with higher milk production in cows fed *pre-partum* a diet with higher amount of ruminally available carbohydrates. Contrarily Ingvartsen et al. (2001) have found pre-partum concentrate-rich diet to have negative effect on milk production and lactose yield. At the same time in some investigations no effect of pre-partum feeding intensity on milk lactose yield was found (Holcomb et al., 2001; Keady et al., 2001; Agenäs et al., 2003; Rabelo et al., 2003). Milk lactose content is kept quite stable and it's yield is related to milk yield. As in our study ECM yield in group H on w3…w4 was only numerically higher compared to group L, we can just speculate that higher lactose yield observed in group H from w2 onwards might be related to higher ECM yield.

Energy balance, BW and BCS

EB was influenced by treatment (P=0.001) and time (P<0.0001) and by their interaction (P=0.0008), BW by time (P<0.0001) and BCS by treatment (P=0.01) and time (P<0.0001; Table 2).

Reflecting higher *pre-partum* DMI_T EB during the period was more positive in group H as well (Table 2). Marked decline (P<0.0001) from positive EB to NEB occurred from w-1 to w1 in both groups followed by improvement in EB. *Post-partum* EB differed inconsiderably only on w2 (Table 2) being numerically (P=0.13) more positive in group H evidently due to higher DMI_T in group H but comparable ECM yield in groups. Similar EB on w3 and w4 in both groups with concurrent higher DMI_T and ECM in group H may indicate that energy expenditure for milk production can be compensated by increased intake. Doepel et al. (2002) and Rabelo et al. (2003) observed improved *post-partum* intake along with improved energy status in cows fed energy-dense diet *pre-partum*; however, this did not improve production performance. At the same time, although, McNamara et al. (2003b) observed higher intake in cows fed energy-dens diet *pre-partum*, *post-partum* EB of these cows was more negative due to higher milk production.

BW difference between the groups on w-2 and w4 was statistically not significant (Table 2). From w-2 to w4 average BW-loss of cows was 73 kg in group L (P<0.0001) and 65 kg in group H (P<0.0001), however, more pronounced weight loss in group L compared to group H was statistically not significant. BCS was higher in group L throughout the experiment (P=0.02). However, starting on w-2 from 3.25 in group L and from 2.99 in group H there was similar overall BCS decline (P<0,0001) in both groups: 0.43 and 0.44 points respectively, resulting in BCS 2.82 in group L and 2.55 in group H on w4 (Table 2). Comparable *post-partum* EB and similar BW- and BCS-loss in our experimental groups show that improved intake is not always related to improved energy status.

Conclusions

Our results indicate that *post-partum* intake could be improved by increasing amount of concentrates in cows' *pre-partum* diet. The conclusion accords with notion that concentrates stimulating rumen papilla growth promote effective ruminal absorption of nutrients with concurrent increase in intake. Therefore we may suggest that in the present study higher intake in group H from w2 onwards positively influencing production performance, might be related to enhanced absorption of nutrients. At the same time we observed no improvement in the *post-partum* energy status of cows fed higher amounts of concentrates *pre-partum*. We assume that high-producing cows are likely to utilize the extra-energy to increase their milk production rather than to maintain their energy status.

Acknowledgements

Estonian Science Foundation (grants No. 5419 and 5422) for financial support, Dr. M. Ots for fruitful discussions, farm and laboratory technicians for technical assistance and all who have been involved are gratefully acknowledged.

References

1. Agenäs, S., Burstedt, E., Holtenius, K. (2003). Effects of feeding intensity during the dry period. 1. Feed intake, body weight, and milk production. *J. Dairy Sci., 86,* 870-882.
2. Andersen, J. B., Sehested, J., Ingvartsen, L. (1999). Effect of dry cow feeding strategy on rumen pH, concentration of volatile fatty acids and rumen epithelium development. *Acta Agric. Scand., Sect. A, Animal Sci., 49,* 149-155.
3. AOAC. (1990). *Official methods of analyses. 15th ed.* Association of official analytical chemists. Washington DC.
4. Ashes, J. R., Gulati, S. K., Scott, T. W. (1997). Potential to alter the content and composition of milk fat through nutrition. *J. Dairy Sci., 80,* 2204-2212.
5. Bargo, F., Muller, L. D., Kolver, E. S., Delahoy, J. E. (2003). Invited review: Production and digestion of supplemented dairy cows on pasture. *J. Dairy Sci., 86,* 1-42.
6. Broster, W. H., Broster, V. J. (1998). Review: Body score of dairy cows. *J. Dairy Res., 65,* 155-173.
7. Dann, H. M., Varga, G. A., Putnam, D. E. (1999). Improving energy supply to late gestation and early postpartum dairy cows. *J. Dairy Sci., 82,* 1765-1778.
8. Dewhurst, R. J., Moorby, J. M., Dhanoa, M. S., Evans, R. T., Fisher, W. J. (2000). Effects of altering energy and protein supply to dairy cows during the dry period. 1. Intake, body condition, and milk production. *J. Dairy Sci., 83,* 1782-1794.
9. Doepel, L., Lapierre, H., Kennelly, J. J. (2002). Peripartum performance and metabolism of dairy cows in response to prepartum energy and protein intake. *J. Dairy Sci., 85,* 2315-2334.
10. Drackley, J. K. (1999). Biology of dairy cows during the transition period: the final frontier? *J. Dairy Sci., 82,* 2259-2273.
11. Edmondson, A. J., Lean, L. J., Weaver, L. D., Farver, T., Webster, G. A. (1989). Body condition scoring chart for Holstein dairy cows. *J. Dairy Sci., 73,* 68-78.
12. Grummer, R. R. (1995). Impact of changes in organic nutrient metabolism on feeding the transition dairy cow. *J. Anim. Sci., 73,* 2820-2933.
13. Harmon, D. L., Gross, K. L., Krehbiel, C. R., Kreikemeier, K. K., Bauer, M. L., Britton, R. A. (1991). Influence of dietary forage and energy intake on metabolism and acyl-CoA synthetase activity in bovine ruminal epithelial tissue. *J. Anim. Sci., 69,* 4117-4127.
14. Holcomb, C. S., Van Horn, H. H., Head, H. H., Hall, M. B., Wilcox, C. J. (2001). Effects of prepartum dry matter intake and forage percentage on postpartum performance of lactating dairy cows. *J. Dairy Sci., 84,* 2051-2058.
15. Holtenius, K., Agenäs, S., Delavaud, C., Chilliard, Y. (2003). Effects of feeding intensity during the dry period. 2. Metabolic and hormonal responses. *J. Dairy Sci., 86,* 883-891.
16. Hristov, A. N., Ropp, J. K. (2003). Effect of dietary carbohydrate composition and availability on utilization of ruminal ammonia nitrogen for milk protein synthesis in dairy cows. *J. Dairy Sci., 86,* 2416-2427.
17. Ingvartsen, K. L., Aaes, O., Andersen, J. B. (2001). Effect of pattern of concentrate allocation in the dry period and early lactation on feed intake and lactational performance in dairy cows. *Livestock Prod. Sci., 71,* 207-221.
18. Ingvartsen, K. L. & Andersen, J. B. (2000). Integration of metabolism and intake regulation: a review focusing on periparturient animals. *J. Dairy Sci., 83,* 1573-1597.
19. Ingvartsen, K. L., Andersen, H. R., Foldager, J. (1992). Effect of sex and pregnancy on feed intake capacity of growing cattle. *Acta Agric. Scand., Sect. A, Animal Sci., 42,* 40-46.
20. Keady, T. W. J., Mayne, C. S., Fitzpatrick, D. A., McCoy, M. A. (2001). Effect of concentrate feed level in late gestation on subsequent milk yield, milk composition and fertility of dairy cows. *J. Dairy Sci., 84,* 1468-1479.
21. Korhonen, M., Vanhatalo, A., Huhtanen, P. (2002). Effect of protein source on amino acid supply, milk production, and metabolism of plasma nutrients in dairy cows fed grass silage. *J. Dairy Sci., 85,* 3336-3351.
22. Liefers, S. C., Veerkamp, R. F., te Pas, M. F. W., Delavaud, C., Chilliard, Y., van der Lende, T. (2003). Leptin concentrations in relation to energy balance, milk yield, intake, live weight, and estrus in dairy cows. *J. Dairy Sci., 86,* 799-807.
23. Marnila, P. & Korhonen, H. (2003). Colostrum. In Roginski, H. (editor-in-chief) *Encyclopedia of Dairy Sciences.* Academic Press, Elsevier Science Ltd., 473-478.
24. McNamara, S., Murphy, J. J., Rath, M., O'Mara, F. P. (2003b). Effects of different transition diets on energy balance, blood metabolites and reproductive performance in dairy cows. *Livestock Prod. Sci., 84,* 195-206.

25. McNamara, S., O'Mara, F. P., Rath, M., Murphy, J. J. (2003a). Effects of different transition diets on dry matter intake, milk production, and milk composition in dairy cows. *J. Dairy Sci., 86,* 2397-2408.

26. Oll, Ü. (Editor) (1995). *Feeding recommendations for farm animals.* Tartu (in Estonian).

27. Olsson, G., Emanuelson, M., Wiktorsson, H. (1998). Effects of different nutritional levels prepartum on the subsequent performance of dairy cows. *Livestock Prod. Sci., 53,* 279-290.

28. Overton, T. R., Waldron, M. R. (2004). Nutritional management of transition dairy cows: strategies to optimize metabolic health. *J. Dairy Sci., 87 (E. Suppl.),* E105-E119.

29. Rabelo, E., Rezende, R. L., Bertics, S. J., Grummer, R. R. (2003). Effects of transition diets varying in dietary energy density on lactation performance and ruminal parameters of dairy cows. *J. Dairy Sci., 86,* 916-925.

30. Rukkwamsuk, T., Geelen, M. J. H., Kruip, T. A. M., Wensing, T. (2000). Interrelation of fatty acid composition in adipose tissue, serum and liver of dairy cows during the development of fatty liver postpartum. *J. Dairy Sci., 83,* 52-59.

31. Rukkwamsuk, T., Kruip, T. A. M., Meijer, G. A. L., Wensing, T. (1999a). Hepatic fatty acid composition in periparturient dairy cows with fatty liver induced by intake of a high energy diet in the dry period. *J. Dairy Sci., 82,* 280-287.

32. Rukkwamsuk, T., Wensing, T., Geelen, M. J. H. (1998). Effect of overfeeding during the dry period on regulation of adipose tissue metabolism in dairy cows during the periparturient period. *J. Dairy Sci., 81,* 2904-2911.

33. Rukkwamsuk, T., Wensing, T., Geelen, M. J. H. (1999b). Effect of fatty liver on hepatic gluconeogenesis in periparturient dairy cows. *J. Dairy Sci., 82,* 500-505.

34. Rukkwamsuk, T., Wensing, T., Geelen, M. J. H. (1999c). Effect of overfeeding during the dry period on the rate of esterification in adipose tissue of dairy cows during the periparturient period. *J. Dairy Sci., 82,* 1164-1169.

35. Ryan, G., Murphy, J. J., Crosse, S., Rath, M. (2003). The effect of pre-calving diet on post-calving cow performance. *Livestock Prod. Sci., 79,* 61-71

36. Saunja, L. O., Baevre, L., Junkkarinen, L., Pedersen, J., Setälä, J. (1991). A Nordic proposal for an energy corrected milk (ECM) formula. *Perfomance recording of animals: State of the art, 1990. Proceedings of the 27th biennial session of the International Committee for Animal Recording (ICAR), Paris, France, 2-6 July 1990.* EAAP Publication, *50,* 156-157.

37. Sehested, J., Diernæs, L., Møller, P. D., Skadhauge, E. (1997). Ruminal transport and metabolism of short-chain fatty acids (SCFA) in vitro: effect of SCFA chain length and pH. *Comp. Biochem. and Physiol., Part A, 123,* 359-368.

38. Vandehaar, M. J., Yousif, G., Sharma, B. K., Herdt, T. H., Emery, R. S., Allen, M. S., Liesman, J. S. (1999). Effect of energy and protein density of prepartum diets on fat and protein metabolism of dairy cattle in the periparturient period. *J. Dairy Sci., 82,* 1282-1295.