DRY MATTER INTAKE OF THE FIRST-PARITY COWS, BRED IN ESTONIA, AT THE BEGINNING OF LACTATION

O. Kärt, E. Rihma, S. Tölp, T. Kaart.
Institute of Animal Science of Estonian Agricultural University, Kreutzwaldi 1, 51014 Tartu, ESTONIA. Phone: 372 7 313 402, fax: 372 7 313 429, e-mail: vats@eau.ee

Abstract. Precise estimation of dry matter intake (DMI) is a prerequisite for accurate balancing of dairy ration. It is crucially important to estimate DMI as precisely as possible in the first part of lactation, when cows use intensively body reserves, and the increased incidences of metabolic diseases may raise problems in fertility. In the present investigation the DMI of first-parity cows bred in Estonia was estimated at the beginning of lactation. Four groups were formed from pregnant heifers: two from Estonian Holstein breed a) high genetic merit (EHF_t)– 20 cows, b) medium genetic merit (EHF) – 20 cows; one group from Red-and-White Holstein breed (RHF) – 20 cows; and one from Estonian Red breed (EPK) – 20 cows. Two different totally mixed rations (TMR) were fed twice a day – the first ration (contained 12.0 MJ/kg of ME, >100 g/kg of MP, >12 % CF in DM) from calving to 150 days of lactation, and the second ration (contained 11.0 MJ/kg of ME, >95 g/kg of MP, >15 % CF in DM) from calving to the end of lactation. Milk production and DMI were determined twice a month, body weight – once a month. Data from 638 measurements were statistically processed and DMI prediction models for different groups were calculated. The DMI ranged from 5.2 to 31.7 kg/d; days in milk (DIM) – from 1.0 to 232.0, and milk yield from 8.4 to 49.7 kg/d. Within the group DMI correlated positively (P<0.0001) with DIM, body weight (BW), milk yield, DM content in TMR, ME content in TMR and negatively with crude fibre, acid detergent fibre (ADF) and neutral detergent fibre (NDF) content in TMR. All calculated models were statistically significant (P<0.0001), but R^2 was relatively low in all models (0.2070 to 0.4413).

Keywords: dry matter intake, intake prediction.

ESTIJOJE VEISIAMŲ PIRMAVERŠIŲ KARVIŲ ORGANIZMO SAUSŲJŲ MEDŽIAGŲ PASISAVINIMAS LAKTACIJOS PRADŽIOJE

Santrauka. Tikslus sausosios medžiagos pasisavinimo (SMP) nustatymas - būtina prielaida pieningų karvių raciono subalansavimui. Ypatingai svarbu nustatyti SMP pirmoje laktacijos pusėje, kai karvės intensyviai naudoja organizmo rezervus, o padidėjęs medžiagų apykaitos sutrikimų skaičius gali sukelti medžiagų apykaitos problemų. Šiuose tyrimuose buvo nustatytas SMP pirmaveršių karvių, veisiamų Estijoje, organizme laktacijos pradžioje. Buvo sudarytos keturios veršingų telyčių grupės: dvi iš Estijos holšteinų veislės karvių a) aukštos genetinės vertės (EHF_t)-20 karvių, b) vidutinės genetinės vertės (EHF)-20 karvių; viena grupė iš žalmargių holšteinų veislės (RHF)-20 karvių; viena iš Estijos žalųjų veislės (EPK)-20 karvių. Jos buvo šeriamos dviem skirtingais sumaišytais racionais du kartus per dieną – pirmuoju racionu (kuriame buvo 12,0MJ/kg AE, >100g/kg MP, >12% ŽL sausojoje medžiagoje) nuo apsiveršiavimo iki 150 laktacijos dienos, o antruoju racionu (kuriame buvo 11,0MJ/kg AE >95g/kg MP, >15% ŽL sausojoje medžiagoje) – nuo apsiveršiavimo iki laktacijos pabaigos. Pieno gamyba ir SMP buvo nustatomi du kartus per mėnesį, kūno svoris – kartą per mėnesį. 638 matavimų duomenys buvo apdoroti statistiškai ir apskaičiuotas SMP prognozavimo modelis skirtingoms karvių grupėms. SMĮ svyravo nuo 5,2 iki 31,7 kg/d., laktacijos dienų skaičius (LDS) – nuo 1,0 iki 232,0, o pieno gamyba – nuo 8,4 iki 49,7 kg/d. Grupės viduje SMP teigiamai koreliavo su LDS (p<0,0001), kūno svoriu (KS), pieno gamyba, sausos medžiagos kiekiu racione, AE kiekiu racione ir neigiamai – su žalia ląsteliena, rūgštimis skaidomos ląstelienos (ADF) ir neutraliai skaidomos ląstelienos (NDF) kiekiu racione. Visi apskaičiuoti modeliai buvo statistiškai patikimi (P<0,0001), bet visuose R^2 buvo palyginti mažas (0,2070…0,4413).

Raktažodžiai: sausos medžiagos pasisavinimas, pasisavinimo prognozavimas.

Introduction. In lactating dairy cattle the estimation of dry matter intake (DMI) is fundamentally important for the formulation of diets to prevent mistakes in feeding, to reduce incidences of metabolic diseases and to improve fertility parameters of cows. Many factors affecting voluntary DMI are investigated, many hypotheses and theories are proposed. It seems that the theories based on physical fill of the reticulorumen are most thoroughly investigated and developed (Allen, 1996). Theories based on metabolic-feedback factors (Van Vuuren et al., 1995) and oxygen consumption (Allen, 2000) need further promotion.

Several DMI prediction equations have been developed and several factors have been used to estimate DMI. Most frequently used variables in multiple regression equations are live weight, milk yield, state of lactation (days in milk, or week of lactation), concentrate supplementation. Somewhat less used variables are dry matter, crude protein, crude fibre and neutral detergent fibre content in forages, organic matter digestibility, parity of cows, *etc*. (NRC 2001, Forbes, 1988; Holter *et al.*, 1997).

The aim of the experiment was to investigate DMI of first-parity cows bred in Estonia at the beginning of lactation and to find factors affecting it.

Materials and Methods. Four groups from pregnant heifers were formed:

- Estonian Holstein breed with high genetic merit (EHF_t) – 20 cows

- Estonian Holstein breed with medium genetic merit (EHF) – 20 cows
- Red-and-White Holstein breed with medium genetic merit (RHF) – 20 cows
- Estonian Red breed with medium genetic merit (EPK) – 20 cows

Two different TMR were fed twice a day at (8.00 a.m. and at 17.00 p.m). Dry matter (DM) of the first ration contained 12 MJ/kg of ME, >100 g/kg of MP and >13 % CF, the second ration contained in DM 11 MJ/kg of ME, >95 g/kg of MP and>15 CF. First TMR was fed from calving to 150 DIM; second - from 150 DIM to the end of lactation. For formulation of the first ration wilted grass silage, hay, barley and corn meal, oil-rich (11 % of crude fat) rapeseed cake, soybean meal, rapeseed oil (0.5 kg per cow) and vitamin-mineral mixture were used. From the second ration rapeseed oil and soybean meal were excluded. First ration contained from 60 to 65 % concentrates; and second ration – from 40 % to 45 % in DM.

Milk production and DMI were determined twice a month; body weight –once a month. All data were processed statistically, using multiple regression procedure of SAS.

Results and Discussion. The studied parameters, having an impact on intake, are presented in Table 1, and their correlation coefficients and statistical significance – in Table 2. As the intake of cows from the 1st day to day 232 of lactation was observed, the range of data variance and standard deviations was quite wide. Thus, daily DMI ranged from 5.2 kg to 31.7 kg, and milk yield from 8.4 kg to 49.7 kg. The data related to ration composition varied relatively less, as it was tried to maintain the nutritive concentration in DM as stable as possible during the trial. Moreover, the trial was carried out in the period when cows were fed the first ration with higher energy content.

Table 1. **Means, standard deviation, and range of variance for estimated parameters (n = 683)**

Variable	Mean	Std Dev	Minimum	Maximum
DMI, kg/d	19.1	3.9	5.2	31.7
DMI, kg/d 100 kg BV	3.6	0.8	1.0	5.5
DIM	85.3	52.2	1.0	232.0
BW, kg	534.1	50.5	413.8	673.3
Milk, kg/d	31.3	5.7	8.4	49.7
4 % FCM, kg/d	30.2	6.2	9.2	53.7
Milk protein, %	3.4	0.3	2.6	4.9
Milk fat, %	3.8	0.7	2.0	7.6
DM in TMR, %	59.3	3.0	51.2	63.6
CP in DM of TMR, %	16.7	0.6	15.1	18.7
MP in DM of TMR, %	10.3	0.3	9.2	10.6
ME in DM of TMR, MJ/kg	11.9	0.3	10.8	12.2
CF in DM of TMR, %	13.6	1.5	12.0	19.4
NDF in DM of TMR	29.3	2.7	25.4	39.3
ADF in DM of TMR	17.3	1.7	15.2	23.2

DMI had a statistically significant positive correlation (P<0.001) with DIM, BW, milk yield and 4 % FCM, TMR dry matter content, TMR energy content; and a negative correlation with dry matter crude fibre, ADF and NDF content. Not always does DMI correlate positively with the number of lactation days. In the studies by Holter et al. (1997) the respective correlation coefficient was –0.25, whereas in our trial it was +0.14. The difference confirms the circumstance that the effect of a lactation day on intake is not linear during the whole lactation period (Friggens *et al.*, 1997).

The negative effect of the content of cell wall matter on dry matter intake has been proved well (Holter *et al.*, 1996). It is not surprising that the crude fibre content of feed correlates with intake on the same level as with the NDF content of feed (Giger-Reverdin, 1995). However, it was somewhat surprising that CP and MP content did not correlate quite well with DMI. Still, in several studies (Chamberlain *et al.*, 1996; Sutton *et al.*, 1994) the DMI has increased after an increase in the protein content of a ration.

All statistically significant factors were considered in a multiple regression procedure to find an equation for DMI prediction (Table 3). As far as the different indicators of cell wall matter of a feed ration are concerned, only the crude fibre content was used. This was due to the fact that most Estonian feed laboratories determine this characteristic in the course of routine feed analysis, moreover, the NDF content of a feed ration did not show a better correlation with intake compared with the CF content of the ration.

Based on the obtained data, five models were calculated for all the tested cows as a mean, and also for each test group separately. We can see that the models describe the intake quite poorly (R^2=0.2070), although all the models are statistically significant (P<0.0001). The effect of the different factors on intake is also quite diverse. While the effect of BW on DMI was positive as a mean of all the groups (however, statistically not significantly), it was negative in the RHF group. Similarly, as far as the effect of ME of the ration on intake is concerned, it was negative in the EHF_t and EHF groups while it was positive in case of all the other groups.

Table 2. **Correlation coefficients and their statistical significance among estimated parameters**

Variable	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. DMI, kg/d	0.89 <0.0001	0.14 0.0002	0.13 0.0008	0.33 <0.0001	0.27 <0.0001	-0.04 0.2832	-0.07 0.0604	0.15 <0.0001	0.08 0.0367	0.11 0.0045	0.18 <0.0001	-0.28 <0.0001	-0.28 <0.0001	-0.22 <0.0001
2. DMI, kg/d 100 kg BV	1.0	0.16 <0.0001	-0.33 <0.0001	0.21 <0.0001	0.17 <0.0001	-0.05 0.2029	-0.04 0.3016	0.16 <0.0001	0.12 0.0014	0.15 0.0001	0.16 <0.0001	-0.22 <0.0001	-0.23 <0.0001	-0.16 <0.0001
3. DIM		1.0	-0.09 0.0228	-0.16 <0.0001	0.18 <0.0001	-0.13 0.0008	-0.10 0.0083	-0.30 <0.0001	-0.56 <0.0001	-0.68 <0.0001	-0.63 <0.0001	0.49 <0.0001	0.40 <0.0001	0.45 <0.0001
4. BW, kg			1.0	0.23 <0.0001	0.17 0.0001	0.02 0.6413	-0.08 0.0298	-0.03 0.4635	0.11 0.0049	0.11 0.0026	0.13 0.0008	0.05 0.1416	0.08 0.0375	0.06 0.0940
5. Milk, kg/d				1.0	0.87 <0.0001	0.05 0.1958	-0.05 0.1540	0.15 <0.0001	0.09 0.0105	0.14 0.0002	0.23 <0.0001	-0.27 0.0001	-0.25 <0.0001	-0.25 <0.0001
6. 4 % FCM, kg/d					1.0	0.19 <0.0001	0.44 <0.0001	0.13 0.0005	0.11 0.0035	0.16 <0.0001	0.25 <0.0001	-0.27 <0.0001	0.26 <0.0001	-0.27 <0.0001
7. Milk protein, %						1.0	0.28 <0.0001	-0.01 0.7914	0.03 0.4216	0.07 0.0864	0.09 0.0241	-0.11 0.0050	-0.10 0.0073	-0.09 0.0185
8. Milk fat, %							1.0	0.01 0.7344	0.06 0.1163	0.09 0.0246	0.10 0.0070	-0.08 0.0419	-0.08 0.0426	-0.10 0.0108
9. DM in TMR, %								1.0	0.16 <0.0001	0.46 <0.0001	0.47 <0.0001	-0.48 <0.0001	-0.45 <0.0001	-0.52 <0.0001
10. CP in DM, %									1.0	0.80 <0.0001	0.69 <0.0001	-0.52 <0.0001	-0.33 <0.0001	-0.51 <0.0001
11. MP in DM, %										1.0	0.89 <0.0001	-0.76 <0.0001	-0.58 <0.0001	-0.76 <0.0001
12. ME in DM, %											1.0	0.87 <0.0001	-0.70 <0.0001	-0.90 <0.0001
13. CF in DM, %												1.0	0.90 <0.0001	0.92 <0.0001
14. NDF in DM, %													1.0	0.77 <0.0001
15. ADF in DM, %														1.0

Table 3. **Regression equations for predicting *ad libitum* DMI cows of different breeds at the beginning of lactation**

	Mean		EHF_t		EHF		RHF		EP	
R^2 P DVM[1], kg/d Root MSE	0.2673 < 0.0001 19.14 3.37		0.4413 < 0.0001 20.14 3.47		0.3945 < 0.0001 18.78 3.03		0.3649 < 0.0001 18.65 2.98		0.2070 < 0.0001 19.01 3.18	
Variable	Estimate	P	Estimate	P	Estimate	P	Estimate	P	Estimate	P
Intercept	7.7687	0.5587	61.986	0.0642	29.833	0.3109	5.1104	0.8340	-	0.6058
BW, kg	0.0042	0.1155	0.0209	0.0036	0.0078	0.1137	-	0.0784	0.0075	0.1550
DIM	0.0303	<0.000	0.0296	0.0003	0.0219	0.0005	0.0406	<0.000	0.0160	0.0056
Milk, kg/d	0.1891	<0.000	0.2243	<0.000	0.1922	<0.000	0.3050	<0.000	0.0997	0.0367
DM in TMR, %	0.0679	0.1701	0.0950	0.4295	0.1843	0.0233	0.1712	0.1165	-	<0.000
ME in DM,MJ/kg	0.6559	0.4607	-	0.0835	-	0.4870	0.7084	0.6844	4.3383	0.0036
CF in DM, %	-	<0.000	-	0.0002	-	0.3959	-	0.0295	-	0.1280

[1] DVM – dependent variable mean

The effect of DIM on DMI was positive in cases of all models. Assuming that the effect of DIM on intake during a lactation cycle is a curve line, not linear, we squared the DIM in further calculations. Although the share of the DIM increased in the model, the whole model did not describe the intake more effectively and the root MSE did not decrease.

As the processed models do not describe the intake of the first-parity cows within the tested period sufficiently well, we comprised a new database and computed a new model to predict DMI during the first 120 days of lactation. The processed models, regarding the means of the groups for both the complete test period and for the first 120 days of lactation, are presented in Table 4. In case the data concerning the first 120 days of lactation were used to compute the model, a slight increase in the R^2 was observed, however, the model was still not precise enough for prediction of DMI. Comparing the factors used in the previous model with those of the new one, the effect of ME of the ration on DMI transformed strictly negative. The effect of dry matter content on intake became negative as well, although it was not statistically significant. The effect of the CF of dry matter on intake also changed significantly. Whereas its effect on intake was statistically significant in the first model, its effect was considerably weaker and it was stati stically insignificant in the new model.

The effect of concentrates and fat on intake explains the negative effect of ME of the ration on intake in the new model. Several researchers have recognised depression to DMI by substitution of high level of concentrates or fats to ration (Arieli *et al.*, 2001; Rihma and Kärt, 2000). As we used relatively big amounts of concentrates and fat to balance the content of energy in TMR in our trials, the results are fairly logical.

Table 4. **Regression equations for predicting *ad libitum* DMI of cows at the beginning of lactation by different DIM**

	0…232 DIM		0…120 DIM	
R^2	0.2673		0.3446	
P	< 0.0001		< 0.0001	
DVM[1], kg/d	19.14		19.18	
Root MSE	3.37		3.25	
Variable	Estimate	P	Estimate	P
Intercept	7.76871	0.5587	122.51503	<0.0001
BW, kg	0.00423	0.1155	0.000607	0.0457
DIM	0.03033	<0.0001	0.05460	<0.0001
Milk, kg/d	0.18913	<0.0001	0.18070	<0.0001
DM in TMR, %	0.06791	0.1701	-0.05862	0.2661
ME in DM,MJ/kg	0.65592	0.4607	-8.90041	<0.0001
CF in DM, %	-0.82753	<0.0001	-0.41686	0.0877

[1] DVM – dependent variable mean

There are two circumstances which allow us to explain why the effect of crude fibre became insignificant in the new model. First, this was due to the fact that the role of the other factors increased considerably in the new model. Second, during the first 120 days of lactation the ration was richer in energy, while the crude fiber content was low and relatively constant. In the first model, the feed ration which was fed after the 150th day of lactation and the crude fibre content of which was significantly higher, has also been taken into consideration.

Still, why do the processed models describe the DMI at the beginning of lactation too modestly? A certain explanation can be found on Figure 1.

We can see that the TMR intake of different trial groups varied largely at the beginning of lactation. The intake of EHF_t was markedly smaller in the first weeks of lactation, compared with other groups. On the other hand, since the second month of lactation their DMI was significantly higher, compared with other groups. The maximum DMI also varied among different groups. While the maximum DMI of cows of EPK and EHF groups was observed on the 80th day of lactation, then that of the EHF_t group was revealed much later – on days from 100 to 110 of lactation. In this study, the maximum DMI of RHF group was not yet achieved by the 120th day of lactation.

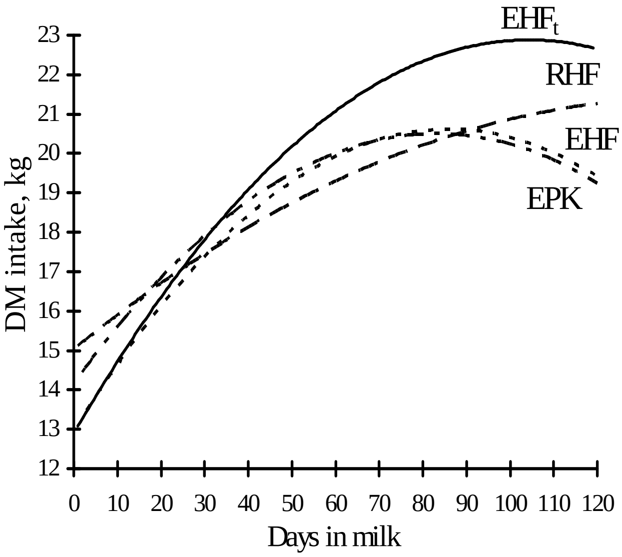

Figure 1. **Dry matter intake of investigated breed groups at the beginning of lactation**

Conclusions. The present study indicated, that the DMI of the first-parity cows differed highly at the beginning of lactation. The studied factors, affecting the intake, do not give a sufficient description of the TMR dry matter intake. To increase the plausibility of regression equation, it is obviously expedient to include in the equation some other factors having an impact on intake. To predict DMI of TMR, it could be reasonable to find different regression equations for the cows of different breeds.

Acknowledgements. The authors are grateful to Estonian Science Foundation (Grant 3707) and to Ministry of Agriculture for financial support.

References

1. Allen, M.S. Effects of diet on short-term regulation of feed intake by lactating dairy cows. J. Dairy Sci., 2000, 83, p. 1598 - 1624.
2. Arieli, A., Abramson, S., Mabjeesh, S.J., Zamwel, S., Bruckental, I. Effect of site and source of energy supplementation on milk yield in dairy cows. – J. Dairy Sci., 2001, 84, p. 462 - 470.
3. Allen, M.S. Physical constraints on voluntary intake of forages by ruminants. J. Animal Sci., 1996, 74, p. 3063 - 3075.
4. Chamberlain, D.G., Martin, P.A., Robertson, S. Optimizing compound feed use in dairy cows with high intake of silage. In: Recent developments in ruminant nutrition 3. Ed. Garnsworthy and Cole, Nottingham, 1996, p. 245 - 263.
5. Forbes, J.M. The prediction of voluntary intake by the dairy cow. In: *Nutrition and lactation in the dairy cow, edited by* Garnsworthy, P,C., Nottingham, 1988, p. 294 - 312.
6. Friggens, N.C., Emmans, G.C., Oldham, J.D., Kyriazakis, I., Veerkamp, R.F., Chalmers, J.S. Food intake by cows on total mixed rations of fixed composition. In: *Proceeings of the British Society of Animal Science*, 1997, p. 7.
7. Giger-Reverdin, S. Review of the main methods of cell wall estimation: interest and limits for ruminants.Animal Feed Science Technology, 1995, 55, p. 295 - 334.
8. Holter, J.B., West, J.W., McGilliard, M.L. Predicting *ad libitum* dry matter intake and yield of Holstein cows.J. Dairy Sci., 1997, 80, p. 2188 - 2199.

9. NRC. Nutrient requirements of dairy cattle, Seventh revised edition, Washington, D.C., 2001, 381 pp.

10. Rihma, E., Kärt, O. Dairy cow´s intake of silage prepared from different grass. In: Proc. of the *International Conference of Animal Nutrition in Tartu*, 2000, p. 22 - 29.

11. Sutton, J.D., Aston, K., Beever, D.E., Fisher, W.J. Milk production from grass silage diets: the relative importance of the amounts of energy and crude protein in the concentrates. Animal Production, 1994, 59, p. 327 - 334.

12. Van Vuuren, A.M., Huhtanen, P., Dulphy J.-P. Improving the feeding and health value of ensiled forages. In: *Recent developments in the nutrition* of *herbivores*, Proc. of the IVth international symposium on the nutrition of herbivores, Clermont-Ferrand (France), September 11-15, 1995, p. 279 - 307.

2002 05 30