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Feeding of high producing dairy cows according to rumen undegradable protein requirements in grass silage based diet

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Abstract. The experiment was performed with 21 Ayshire cows 4—16 weeks post calving. Cows received restricted amounts (according to calculated intake) of unwilted grass silage, preserved with a mixture of acetic acid and formalin and two kilograms of hay/cow/day. A concentrate mixture including dried and propionic acid treated barley and oats together with a mineral-vitamin mixture was given 0.3 kg/kg FCM.

During the standardization period (2 weeks) protein feeding of the cows was performed according to the DCP requirements and the diet was supplemented with soybean meal if necessary. For the adaptation period (3 weeks) and the comparison period (8 weeks) the cows were divided in 3 equal groups of 7 cows (G1, G2, G3). G 1 had no protein supplement in the diet. The diets of G 2 and G 3 were supplemented correspondingly either with rapeseed meal or formaldehyde treated urea on the basis of the UDP (undegradable feed protein) requirements (G2) and the DCP requirements (G3) of the cows.

Efficient protein degradabilities in the total diets during the comparison period varied from 77 to 85 % when the determinations were made with the nylon bag technique. The highest degradabilities were found for the diet of G 3 and the lowest for G 2. Significantly ($P < 0.05$, 0.01) the highest yields of FCM and milk protein were recorded for Group 2 (G2) in which the cows received protein supplement according to their UDP requirements. Using a factorial approach, conversion of protein absorbable in the small intestine to milk protein was calculated to be 66.5 ± 0.8 % when all the cows in three groups were taken into account.

Introduction

In ruminant feeding, the importance to feed the animal correctly in terms of protein requirements of rumen microbes and the animal has, owing to increased knowledge in this field, become one of the most central points. Rumen microbes need a certain level of RDP in the diet for maximal protein synthesis and feed digestion. However, it is very important to feed e.g. a high yielding dairy cow correctly in situations, in which

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the capasity of ruminal protein synthesis should be exceeded in order to meet protein requirement of the cow. The importance of use of relatively undegradable feed protein as a supplement has been illustrated by KAUFMANN (1979).

Attempts to develop systems to plan feeding of ruminants in terms of requirements of ruminally degradable (RDP) and undegradable protein (UDP) have been made by many scientists as reviewed by BLACK *et al.* (1982). The aim of this experiment was to study the use of one of these systems (ARC, ANON 1980) in planning of diet for high yielding dairy cows in particular feeding conditions. Basal diet of the cows was composed by feeds typical in the feeding of Finnish dairy cattle. As rapeseed meal is one of the most important protein concentrates in Finland, it was chosen to be used as a UDP-source in the experiment. Formaldehyde-treated urea (HCHO-urea) was used as a RDP-source (fed on the basis of digestible crude protein, DCP) because it was suggested to be a better NPN-source than an ordinary urea for high yielding dairy cows (SETÄLÄ and SYRJÄLÄ-QVIST 1982b).

Experimental procedures

Animals and diets

Milk production trial was made with 21 Ayshire cows, which were taken for the trial in two blocks about 4 weeks after calving. The parturition was the second for all the cows.

Each cow had an experimental period of 13 weeks including
standardization period, 2 weeks
adaptation period, 3 weeks
comparison period, 8 weeks.

The cows were fed individually twice a day and they received 2.0 kg hay/cow/d and grass silage according to calculated DM intake during the experiment. Hay was field-dried and baled and grass silage was unwilted, preserved with Viher acid (20 % formaldehyde, 30 % acetic acid; chemical composition, see Table 1) using 5 l pre-

Table 1. Chemical composition and feeding value of the feeds in the experiment.

	Hay	Grass silage[1]	Concentrate mix	Rapeseed meal	Soybean meal	HCHO-urea
Dry matter, %	86.1 ± 0.7	22.3 ± 0.7	84.1 ± 0.5	89.0 ± 1.6	83.5 ± 1.3	99.3
% in dry matter						
Ash	8.0 ± 0.3	7.5 ± 0.2	5.3 ± 0.4	7.7 ± 0.2	6.0 ± 0.7	—
Crude protein	11.1 ± 0.2	14.9 ± 0.4	12.0 ± 0.2	36.8 ± 0.4	51.5 ± 0.5	46.3[3]
Crude fibre	34.6 ± 0.4	32.1 ± 0.7	9.1 ± 0.3	15.2 ± 0.3	11.3 ± 0.9	—
Ether extracts	2.6 ± 0.1	6.3 ± 0.3	3.9 ± 0.1	4.0 ± 0.1	1.9 ± 0.5	—
N-free valuable nutrients	43.5 ± 0.6	38.6 ± 1.2	69.6 ± 0.5	36.3 ± 0.5	29.2 ± 1.6	—
g DCP/kg DM	71.1 ± 3.1	104.6 ± 5.8	91.2 ± 1.2	301.6 ± 3.0	463.8 ± 4.3	—
f.u./kg DM[2]	0.47 ± 0.04	0.73 ± 0.11	1.08 ± 0.03	0.86 ± 0.07	1.09 ± 0.03	
MJ ME/kg DM	8.7 ± 0.1	9.3 ± 0.2	12.4 ± 0.1	10.5 ± 0.1	12.4 ± 0.1	—
Degradability, %[4]						
Organic matter	48.9 ± 2.0	61.4 ± 2.3	77.3 ± 1.3	48.5 ± 1.5	60.0	—
Crude protein	63.1 ± 1.8	79.6 ± 2.6	86.8 ± 1.1	49.1 ± 2.5	60.0	100.0

[1] pH 3.8, % in DM: soluble sugars 3.2, lactic acid 7.6, acetic acid 1.7, propionic acid 0.06
% in total N: NH_3-N 5.9, water soluble N 52.9

[2] f.u. = feed unit

[3] N-%

[4] only one determination for soybean meal; for the others 8 determinations/feed

servative/1000 kg fodder. Feeding of the cows during different periods was performed as follows:

Grass silage and hay were sampled every day during the standardization period. Daily samples were bulked into one sample/week.

	Standardization period			Comparison period		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
Hay, kg/cow/d	2.0	2.0	2.0	2.0	2.0	2.0
Grass silage[1]	re-strict.	re-strict.	re-strict.	re-strict.	re-strict.	re-strict.
Concentrates, kg/kg 4 % milk[2]	0.3	0.3	0.3	0.3	0.3	0.3
Soybean meal	DCP[3]	DCP[3]	DCP[3]	—	—	—
Rapeseed meal	—	—	—	—	UDP[4]	—
HCHO-urea[5]	—	—	—	—	—	DCP[3]

[1] According to calculated DM intake (Salo et al. 1982)

[2] Propionic acid preserved or dried (50 % : 50 %) mixture of barley and oats (1:1) 98 %, vitamin-mineral mixture 2.0 % (g/kg:Ca 175, P 80, Na 95, Mg 50, Se 0.01)

[3] According to DCP requirements of the cows (calculations, see later in the text)

[4] According to UDP requirements of the cows (calculations, see later in the text)

[5] 1.5 % HCHO, see Setälä and Syrjälä-Qvist (1982 a)

During the standardization period the cows received soybean meal as a protein supplement according to their DCP requirements. After this period, the cows were divided in three as equal as possible groups (7 cows/group) according to their milk yields and liveweight. The cows in Groups 2 and 3 were gradually accustomed to their new feeds, rapeseed meal or HCHO-urea, respectively. At the same time soybean was gradually withdrawn from the diet of the cows in Groups 1, 2 and 3.

The cows were weighed at the beginning of each period, at the end of the experiment and every fourth week during the comparison period.

Sampling and analyses

Milk produced was weighed and recorded for each cow at every milking. A milk sample for each cow was taken from the milk of two days so that the sample was composed by proportional amounts of milk produced at each milking. Fat and protein contents of the samples were analyzed with the infrared analyzer (IRMA).

Concentrates were sampled always while making the mixture.

During the adaptation and comparison periods roughage and concentrates were sampled every second week so that the samples would represent the feeds which were going to be fed during the next 2 weeks.

Samples of soybean meal were taken every day while preparing the feeds for each cow during the standardization period. Rapeseed meal and HCHO-urea were sampled in a similar way as grain concentrates during the adaptation and comparison periods. Feed refusals were sampled every day, stored at +4°C and bulked into one sample/cow/two weeks.

DM contents of the samples were determined in an oven at +103—+105°C and samples for feed analyses were dried in vacuum (except urea) oven at +50°C. Because of the loss of volatile substances in DM determination, DM content of the silages was corrected according to the volatile fatty acids in silage as described by Setälä *et al.* (1979).

Chemical composition of the feeds and feed refusals was analyzed according to the standard methods. The quality of the grass silage (pH, sugars, lactic acid, NH_3 -N, VFA, water-soluble N) was determined as described by SETÄLÄ *et al.* (1979).

Degradability of feed proteins in the rumen was determined during the comparison period using the nylon bag technique. Feed samples, taken as described earlier in this chapter, were incubated in the rumen of a sheep receiving the same feeds which were given to the cows. The feeding level and the proportions of feeds in the diet were also the same as in the diets of the cows. The incubation procedure followed in the study has been described in details by SETÄLÄ (1983 a). Values for efficient protein degradabilities were obtained for each period of two weeks and the feeding of the cows was planned according to these results.

Our unpublished results with urease enzyme *in vitro* showed that HCHO-urea seemed to be completely degradable in the rumen.

Feeding of the cows was calculated and adjusted at the beginning of each week.

Calculations and statistical procedures

The energy and digestible crude protein required for maintenance and production were calculated as described by SETÄLÄ and SYRJÄLÄ-QVIST (1982 b). Maintenance requirements for energy and protein were 4.0 f.f.u. per 500 kg liveweight and 75 g DCP per maintenance f.f.u. (BREIREM 1969). The energy requirement for liveweight change was 2 f.f.u./kg liveweight change. Energy and protein requirements for milk production were 0.4 f.u./kg FCM and 57 g DCP/kg FCM, respectively.

The amount of the degradable (RDP) and the undegradable feed protein (UDP) in the feeds was evaluated so that the effect of the feeding level (changes in outflow rates) was taken into account (see SETÄLÄ 1983 a). The RDP and UDP intake of the cows was calculated using these values. The UDP requirement of the cows was calculated according to the ARC system (ANON 1980). However, the microbial protein synthesis was adjusted for the grass silage diet, and the value used for the efficiency of the synthesis was 25 g N/kg OMAppFR (organic matter apparently fermented in the rumen) (MÜHLBACH & KAUFMANN 1979, ARMSTRONG 1980). Although in the ARC system the absorption of the protein in the small intestine is given as an apparent absorption, in the calculations metabolic nitrogen excretion was taken into account as a requirement according to BURROUGHS *et al.* (1975). On the basis of UDP deficiency the diet of the cows in Group 2 was supplemented with rapeseed meal. Recalculations for the standardization period were based on the first determinations of degradability made from feeds for the comparison period.

The yield data were tested by two-way analysis of covariance, where the regression variable was the yield of the standardization period and the treatments were used as factors. The differences between treatment means were tested by the Tukey test (STEEL and TORRIE 1960).

Results and discussion

Feed intake and milk yield

During the comparison period the average relationship (calculated on DM basis) between concentrates and forage was 51.6 : 48.4 in the experiment (Table 2). The corresponding values for Groups 1, 2 and 3 were 51.9 : 48.1, 53.4 : 46.6 and 49.6 : 50.4, respectively.

The cows did not eat willingly the feeds, especially concentrates and silage, and refusals were left in all three groups throughout the experiment. Low palatability of grass silage was caused by relatively high bulkiness, especially at the beginning of the trial. However, reasons for poor palatability of concentrates remained unclear, although results of this kind were also reported by LINDELL (1982), when the cows were fed in a

Table 2. Average feed consumption of the cows during the standardization and comparison period (G = group, RSM = rapeseed meal, SBM = soybean meal)

	DM intake/cow/day						
	Hay	Grass silage	Concentrate mix	RSM	SBM	HCHO-urea	Total
Standardization period							
G 1, DCP/SBM	1.3	4.4	7.1	—	0.7	—	13.5
G 2, DCP/SBM	1.3	4.9	6.5	—	0.6	—	13.3
G 3, DCP/SBM	1.1	5.7	8.0	—	0.8	—	15.7
Comparison period							
9—12 weeks from calving							
G 1, no supplement	1.3	5.2	7.4	—	—	—	13.9
G 2, UDP/RSM	1.3	5.8	7.8	0.7	—	—	15.6
G 3, DCP/HCHO-urea	1.2	5.7	7.0	—	—	0.14	14.0
13—16 weeks from calving							
G 1, no supplement	1.3	5.4	7.0	—	—	—	13.7
G 2, UDP/RSM	1.3	6.0	7.6	0.4	—	—	15.3
G 3, DCP/HCHO-urea	1.4	5.2	6.0	—	—	0.096	12.8

Table 3. Average daily milk, fat, and protein yields, and the composition of the milk of the cows in the experiment (G, RSM, SBM, see Table 2)

	kg/cow/d				% in milk	
	Milk	FCM	Fat	Protein	Fat	Protein
Standardization period						
G 1, DCP/SBM	25.6	27.6	1.16	0.73	4.53	2.87
G 2, DCP/SBM	24.8	28.4	1.23	0.70	4.99	2.83
G 3, DCP/SBM	26.7	27.3	1.21	0.78	4.47	2.93
Comparison period						
9—12 weeks from calving						
G 1, no supplement	22.8^{c}	24.3^{ac}	1.01^{c}	0.67^{c}	4.40	2.96
G 2, UDP/RSM	25.2^{d}	26.4^{bc}	1.09^{c}	0.77^{d}	4.36	3.08
G 3, DCP/HCHO-urea	21.8^{c}	22.4^{d}	0.91^{d}	0.65^{c}	4.21	3.04
13—16 weeks from calving						
G 1, no supplement	20.6^{c}	22.4^{ac}	0.94^{c}	0.62^{ac}	4.55	3.03
G 2, UDP/RSM	23.4^{ad}	25.3^{bc}	1.06^{c}	0.74^{d}	4.56	3.19
G 3, DCP/HCHO-urea	18.4^{bd}	19.4^{d}	0.80^{d}	0.57^{be}	4.40	3.18

$^{a-b}$, $P < 0.05$, means between groups differed significantly
$^{c-e}$, $P < 0.01$, means between groups differed significantly

restrictive way. Waldern (1973) also suggested that rapeseed meal might be less palatable than soybean meal, but problems in palatability have not been observed with acid-preserved grains (Pohjanheimo and Ettala 1971) or HCHO-urea (Setälä and Syrjälä-Qvist 1982 b).

The experiment did not start until 4 weeks after calvings of the cows, but the average yields of FCM were relatively high being 28—30 kg FCM/cow/day at the beginning of the standardization period.

Cows in Group 2 produced significantly ($P < 0.05$, 0.01) more FCM than cows in Groups 1 or 3 (Table 3). Moreover, yield of protein ($P < 0.01$) was also significantly higher in Group 2, although there were not significant differences in milk fat-% or protein -% between groups.

The poorest yields were reported for Group 3 receiving HCHO-urea as a supplement of the basal diet. According to Setälä and Syrjälä-Qvist (1982 b) HCHO-urea gave higher milk yields than an ordinary urea especially when cows produced more than 15 kg FCM/day. Moreover, they also suggested (Setälä and Syrjälä-Qvist 1982 a) that HCHO-urea could successfully be used as a supplement even in diets having crude protein content up to 15—16 % in DM e.g. in the feeding of high-producing dairy cows fed on the basis of DCP.

However, the yield data of Group 3 cannot directly be compared with the data of the other groups. In Group 3, 6 of the seven cows suffered from a severe mastitis during the experiment. In Groups 1 and 2 mastitis was observed in 2 and 1 cows, respectively. High mastitis frequency in Group 3 was not caused by feeding. Relatively high cell counts were found afterwards in the milk of the cows in this group already in the standardization period. However, coincidentally most of the cows in Group 3 had mastitis although they were divided in groups on the basis of other factors.

The cows received less energy and protein (Table 4) than they required according to calculated standards and this was mainly caused by the low palatability of concentrates. Based on feed units the cows received energy if expressed as per cent of the requirement as follows: Standardization period, Group 1, 2 and 3, 81, 76 and 90; Comparison period, Groups 1, 2 and 3, 92, 96 and 95 respectively. The corresponding weight losses as an average in grams/cow/day were -1071, -990 and -702 for the standardization period; -28, -237 and -330 for the comparison period.

If the amount of mobilized body energy (weight loss) is increased the need of absorbed protein in the tissues is also increased so that a balance between energy and protein is obtained in the tissues. Ørskov *et al.* (1981) suggested that in the situations of energy undernutrition the UDP supplementation is advisable. According to Lee *et al.* (1974), Oldham *et al.* (1982) and Tyrrell *et al.* (1982) UDP-supplementation of the diet causes an increased tissue catabolism due to increased secretion of growth hormone. However, in the case of severe undernutrition UDP-supplementation could lead the cow to ketosis (Webster *et al.* 1982).

Oldham *et al.* (1979) reported an increase in the yields of milk, fat and protein when

Table 4. Average intake of digestible crude protein, ruminally degradable or undegradable protein in ratio to the requirements of the cows (G = group)

	Standardization period			Comparison period					
				9—12 weeks			13—16 weeks		
	G1	G2	G3	G1	G2	G3	G1	G2	G3
g DCP/kg FCM	45.0	41.1	51.7	41.2	47.9	56.4	46.1	49.8	56.9
— % of requirement	79	73	88	74	83	95	81	86	96
RDP intake, g/d	1481	1456	1731	1456	1694	1887	1531	1750	1706
— % of requirement	132	127	150	133	144	174	134	141	162
UDP intake, g/d[1]	644	575	706	319	512	369	325	425	312
— % of requirement	87	81	105	58	80	69	75	81	76
% crude protein in DM of total diet	15.7	15.3	15.5	12.7	14.1	16.1	13.5	14.2	15.8
% RDP in total protein	69.7	71.7	71.0	82.0	76.8	83.6	82.5	80.4	84.5

RDP = ruminally degradable protein (N × 6.25)

UDP = ruminally undegradable protein (N × 6.25)

[1] changes in liveweight were taken into account as in ANON (1980)

urea was substituted in the diet by fish meal. The highest yields of milk and protein were obtained when the ratio of RDP:UDP was between 1.8—2.5. In the present study the average ratio of RDP:UDP was 3.8 ± 0.4.

Castle *et al.* (1983) found an increase in milk yield and in protein content of milk when silage diets were supplemented with various levels of protein concentrates. However, Oldham *et al.* (1982) did not notice changes in milk composition of the cows, when formaldehyde treated and untreated protein concentrates were compared in the diet. According to Forster *et al.* (1983) the effect of UDP supplement on milk composition is dependent on energy status of the cows. When cows were fed in a restricted way with hay-corn silage based diets, UDP supplementation increased milk production, decreased protein-% in milk and had no effect on fat or lactose per cent in milk.

When protein amount in the total diet was reduced using protected protein on similar energy level, changes in milk composition of the cows were not observed (Kaufmann et al. 1982).

Protein metabolism of the cows

The cows managed well with relatively low crude protein levels in the total diet during the comparison period. These results agree with the factorial calculations of Setälä (1983 b) when the feeding of the cows was planned on the basis of UDP requirements.

Because the cows did not eat all the amount of the feeds, they did receive less UDP than they would have required. Intake of RDP was higher than requirements and this was mainly caused by the high degradability of silage protein. Therefore the degradability of crude protein in the total diets was relatively high, varying from 70 to 85 %.

In the present study microbial protein synthesis was evaluated to be 25 g N/kg OMAppFR. The efficiency of synthesis was assumed to be the same in all diets although according to Armstrong (1980) and McAllan and Smith (1983) the efficiency of synthesis might be improved in roughage based diets by protein supplementation. The value chosen for microbial protein synthesis appeared to be slightly higher or lower than suggested in the recent reviews of Thomas (1982) or Miller (1982), respectively.

According to calculations microbial protein covered about 63, or 75 % of the total amount of absorbable protein in the standardization period or in the comparison period, respectively (Table 5). Similar re-

Table 5. Nitrogen utilization of the cows

	Standardization period			Comparison period					
				9—12 weeks			13—16 weeks		
	G1	G2	G3	G1	G2	G3	G1	G2	G3
Protein for the cow									
— microbial, g/d*	1040	1011	1200	1115	1236	1110	1131	1255	1033
— UDP, g/d	644	575	706	319	512	369	325	425	312
— total, g/d	1684	1586	1906	1434	1748	1479	1456	1680	1345
— absorbed protein, g/d**	1179	1110	1334	1003	1223	1035	1019	1176	941
Absorbed protein/ milk protein***	0.66	0.67	0.62	0.72	0.67	0.67	0.65	0.67	0.65

* Amino-N 80 % in total microbial N; synthesis calculated on the basis of OM apparently fermented in the rumen
** Absorbtion 70 %
*** Maintenance requirements are taken into account.

sults have been reported by OVEREND and ARMSTRONG (1982) and MERCHEN and SATTER (1983) although the proportion of microbial protein in the total protein in small intestine may vary if the amount of concentrates in the diet is changed (TELLER *et al.* 1979).

Utilization of absorbed protein into milk protein was not much different in different diets, the average value for utilization being 66.5 ± 0.8 %.

In spite of higher milk yield of the cows, there were not great differences in utilization of absorbed protein when the standardization period is compared with the comparison period. Besides of differences in milk yield and protein feeding (DCP-UDP), there were also different protein sources in the diets of these two periods. Although it was suggested by VARVIKKO *et al.* (1983) that amino acid profile in undegradable protein could be more easily changed by rumen fermentations in rapeseed meal than in soybean meal, this was not supported at least in the present study when protein utilization for the standardization period was obtained with recalculations.

OLDHAM (1978) suggested that absorbed protein was utilized with an efficiency of 65—85 % for protein production, leaving 15—35 % of amino acids to serve as precursors for other purposes, for instance in gluconeogenesis. Efficiency tended to increase with higher energy supply (see also RULQUIN 1982), which could explain the difference in utilization of protein between Group 3 (Standardization period) and Group 1 (Comparison period). Based on the other experimental approach than in the previous study, OLDHAM (1979) suggested the value of 67—72 % for protein utilization.

In the review of BROSTER and OLDHAM (1981) they suggested that in most situations the value of 70 % could be used for both feed and microbial protein when apparent absorption is calculated. However, STORM and ØRSKOV (1982) reported that the efficiency of utilization of absorbed amino acid N from microbial protein might be about 80 %, e.g. higher than used in the present study according to ARC-system. On the other hand, BROSTER and OLDHAM (1981) also concluded that the protein requirement for the cow producing 25—30 kg milk/day is 14.0—14.5 % crude protein in DM of the total diet which is in agreement with the results in the present trial.

In situations, in which undernutrition of energy and protein are used, there are generally problems in the fertility of the cows. In the present study these problems were not observed. There were before the experiment 1.57, 1.60 and 1.40 services/conception for the cows in Groups 1, 2 and 3, whereas during the experiment 1.30, 1.80 and 1.50 services, respectively. However, it must be pointed out that the present study lasted only for 13 weeks which might be too short period for such observations.

In conclusions, it is possible to feed the dairy cow according to the requirements of different protein fractions, e.g. RDP and UDP. If fed in this way, crude protein level in the diet is lower compared to the diet planned on the basis of DCP. In the present study the cows did not receive UDP enough when their UDP requirements were calculated including 2 g N/kg DMI as metabolic nitrogen. However, if this nitrogen amount is not taken into account, the cows received UDP enough to cover their requirements, which shows that the use of apparent absorption in the system takes this N fraction into account when protein requirements of the cows are evaluated.

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References

ANON 1980. The nutrient requirements of ruminant livestock. Technical review by an Agricultural Research Council working party. Commonwealth Agricultural Bureaux. 351 p.

ARMSTRONG, D.G. 1980. Net efficiencies of microbial N synthesis in ruminant livestock. EAAP-publ. 27 (vol. II): 400—411.

BLACK, J.L., FAICHNEY, G.J., BEEVER, D.E. & HOWARTH, B.R. 1982. Alternative systems for assessing the nitrogen value of feeds for ruminants. Forage protein in ruminant animal production, ed. Thomson, D.J., Beever, D.E. and Gunn, R.G. p. 107—118. BSAP, Thames Ditton.

BREIREM, K. 1969. Fornormer. K.K. Heje/Singsaas Lommealmanakk 1: 120. Oslo.

BROSTER, W.H. & OLDHAM, J.D. 1981. Protein quantity and quality for the UK dairy cow. Recent developments in ruminant nutrition, ed. Haresign, W. and Cole, D.J.A. p. 184—214. Butterworths.

BURROUGHS, Wise, NELSON, D.K. & MARTENS, D.R. 1975. Protein physiology and its application in lactating cow: the metabolizable protein feeding standard. J. Anim. Sci. 41: 933—944.

CASTLE, M.E., GILL, M.S. & WATSON, J.N. 1983. Silage and milk production: a comparison between three rates of high-protein concentrate supplementation of grass silages of two digestibilities. Grass and Forage Sci. 38: 135—140.

FORSTER, R.J., GRIEVE, D.G., BUCHANAN-SMITH, J.G. & MACLEOD, G.K. 1983. Effect of dietary protein degradability on cows in early lactation. J. Dairy Sci. 66: 1653—1662.

KAUFMANN, W. 1979. Zur Eiweissverdauung bei Wiederkäuern im Hinblick auf die faktorielle Berechnung des Eiweissbedarfes. Z. Tierphys. Tierernähr. u. Futtermittelk. 42: 326—333.

—, LOTTHAMMER, K-H. & LÜPPING, W. 1982. Zum Einfluss eines verminderten Proteingehaltes der Ration (über Verwendung von geschütztem Protein) auf Milchleistung und einige Blutparameter als Kennzeichen der Leberbelastung. Z. Tierphys. Tierernähr. u. Futtermittelk. 47: 85—101.

LEE, V., RAMACHANDRAN, J. & LI, C.H. 1974. Does bovine growth hormone possess rapid lipolytic activity? Arch. Biochem. Biophys. 161: 222—226.

LINDELL, L. 1982. Effects of different levels of protein to dairy cows. Swedish J. agric. Res. 13: 47—59.

MCALLAN, A.B. & SMITH, R.H. 1983. Effect of dietary nitrogen supplementation on fibre digestion in the rumen. Proc. Nutr. Soc. 42: 50A.

MERCHEN, N.R. & SATTER, L.D. 1983. Changes in nitrogenous compounds and sites of digestion of alfalfa harvested at different moisture contents. J. Dairy Sci. 66: 789—801.

MILLER, E.L. 1982. The nitrogen needs of ruminants. Forage protein in ruminant animal production, ed. Thomson, D.J., Beever, D.E. & Gunn, R.G., p. 79—87. British Society of Animal Production.

MÜHLBACH, P.R.F. & KAUFMANN, W. 1979. Eiweiss-Verfügbarkeit von Formaldehyd-behandelter Grassilage beim Wiederkäuer. Das Wirtschaftseigene Futter 25: 115—132.

OLDHAM, J.D. 1978. Utilization of the end-products of protein digestion for lactation. Ruminant digestion and feed evaluation, ed. Osbourn, D.F., Beever, D.E. & Thomson, D.J. 13.1. — 13.14. Agricultural Research Council.

—, 1979. The effect of lactation on amino acid requirement. Protein metabolism in the ruminant, ed. Buttery, P.J. p. 5.1 — 5.16. Agricultural Research Council.

—, BROSTER, W.H., NAPPER, D.J. & SMITH, T. 1979. Predicted and measured performance of Friesian cows fed on rations calculated to differ in rumen degradable protein and undegradable protein. Proc. Nutr. Soc. 38: 128A.

—, HART, I.C. & BINES, J.A. 1982. Formaldehyde-treated proteins for dairy cows — effects on blood hormone concentrations. Br. J. Nutr. 48: 543—547.

OVEREND, M.A. & ARMSTRONG, D.G. 1982. The digestion of a wilted silage made with and without an additive. Forage protein in ruminant animal production, ed. Thomson, D.J., Beever, D.E. & Gunn, R.G. p. 162—163. British Society of Animal Production.

POHJANHEIMO, O. & ETTALA, E. 1971. Tuoreena säilötty ohra lypsylehmien rehuna. Koetoim. ja Käyt. 5/1971.

RULQUIN, H. 1982. Effects of ruminal infusion of volatile fatty acids and duodenal infusion of caseinate on digestion and metabolism in the dairy cow. 1. Production and digestion. Abstract. Reproduction, Nutrition, Development 22: 905—921.

SALO, M-L., TUORI, M. & KIISKINEN, T. 1982. Rehutaulukot ja ruokintanormit. Helsinki. 70 p.

SETÄLÄ, J. 1983 a. The nylon bag technique in the determination of ruminal feed protein degradation. J. Scient. Agric. Soc. Finl. 55: 1—78.

—, 1983 b. Lypsylehmien valkuaisen tarve ja sen ruokinnalle asettamat vaatimukset (Protein requirements and protein feeding of dairy cows). Työtehoseuran julkaisuja 252: 5—60.

—, SEPPÄLÄ, J., PULLI, S. ja POUTIAINEN, E. 1979. Preliminary studies on the conservation of whole sorghum and corn plant and sugar corn stover for silage. J. Scient. Agric. Soc. Finl. 51: 222—228.

—, & SYRJÄLÄ-QVIST, L. 1982 a. Effect of the crude protein level on the utilization of untreated and formaldehyde-treated urea *in vitro*. J. Scient. Agric. Soc. Finl. 54: 25—31.

—, & Syrjälä-Qvist, L. 1982 b. Untreated and formaldehyde-treated urea as nitrogen sources for lactating dairy cows. J. Scient. Agric. Soc. Finl. 54: 43—52.

Steel, R.G. & Torrie, J.H. 1960. Principles and procedures of statistics. New York. 481 p.

Storm, E. & Ørskov, E.R. 1982. Biological value and digestibility of rumen microbial protein in lamb small intestine. Proc. Nutr. Soc. 41: 78A.

Teller, E., Godeau, J.M. & De Baere, R. 1979. The fate of nitrogen in the various segments of the digestive tract of cows. Z. Tierphys. Tierern. u. Futtermittelk. 42: 262—270.

Thomas, P.C. 1982. Utilization of conserved forages. Forage protein in ruminant animal production, ed. Thomson, D.J., Beever, D.E. & Gunn, R.G. p. 67—76. British Society of Animal Production.

Tyrrell, H.F., Brown, A.C.G., Reynolds, P.J., Haaland, G.L., Peel, C.J., Bauman, D.E. & Steinhour, W.D. 1982. Administration of bovine growth hormone to high yielding dairy cows I. Influence on *in vivo* energy metabolism. J. Dairy Sci. 65, suppl. 1: 120 (P84).

Varvikko, T., Lindberg, J.E., Setälä, J. & Syrjälä-Qvist, L. 1983. The effect of formaldehyde treatment of soyabean meal and rapeseed meal on the amino acid profiles and acid-pepsin solubility of the rumen undegraded protein. J. agric. Sci., Camb. 101: 603—612.

Waldern, D.E. 1973. Rapeseed meal versus soyabean meal as the only protein supplement for lactating cows fed a corn silage roughage ration. Can. J. Anim. Sci. 53: 107—112.

Webster, A.J.F., Simmons, I.P. & Kitcherside, M.A. 1982. Forage protein and the performance and health of the dairy cow. Forage protein in ruminant animal production ed. Thomson, D.J., Beever, D.E. & Gunn, R.G. p. 89—95. British Society of Animal Production.

Ørskov, E.R., Reid, G.N. & McDonald, I. 1981. The effects of protein degradability and food intake on milk yield and composition in cows in early lactation. Br. J. Nutr. 45: 547—555.

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SELOSTUS

Korkeatuottoisten lypsylehmien ruokinta pötsissä hajoamattoman rehuvalkuaisen mukaan nurmisäilörehuun perustuvalla ruokinnalla

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Tutkimus suoritettiin 21 Ayrshire-lehmällä, jotka tulivat kokeeseen keskimäärin 4 viikkoa poikimisen jälkeen. Kokeen kestoaika oli 13 viikkoa, josta 2 viikkoa oli vakiointikautta ja 3 sekä 8 viikkoa vastaavasti siirto- ja vertailukautta.

Lehmät saivat perusväkirehuseosta (kuivattua tai propionihapolla säilöttyä ohraa tai kauraa sekä kivennäisseosta) 0,3 kg/4%-maitokilo sekä 2,0 kiloa heinää/lehmä/d. Säilörehua lehmille annettiin lasketun syöntikyvyn mukaan. Vakiointikaudella lehmien ruokintaa täydennettiin tarvittaessa soijarouheella ja täydennystarve arvioitiin lehmien sulavan raakavalkuaistarpeen perusteella. Vakiointikauden jälkeen lehmät jaettiin kolmeen (R1, R2, R3) seitsemän lehmän ryhmään, joista R1 ei saanut vertailukaudella valkuaistäydennystä, mutta R2:n ja R3:n ruokintaa täydennettiin vastaavasti rypsirouheella tai formaldehydiurealla. Valkuaistäydennyksen tarve R2:lle laskettiin lehmien pötsissä hajoamattoman rehuproteiinin tarpeen mukaan ja R3:lle sulavan raakavalkuaistarpeen mukaan.

Ryhmän 2 lehmien 4%-maitotuotos ja valkuaistuotos olivat merkitsevästi ($P < 0,05, 0,01$) suurimmat vertailukauden aikana. Faktoriaalista laskentatekniikkaa käyttäen lehmien ohutsuolesta imeytyvän proteiinin hyväksikäyttö maidon proteiinin muodostukseen oli 66,5 ± 0,8 %. Eri ruokintojen välillä ei tässä suhteessa ollut selviä eroja.

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