Journal of Animal and Feed Sciences, 9, 2000, 563 – 583

Effects of early lactation concentrate level and glucogenic feed on feed intake, milk production and energy metabolism in dairy cows and heifers*

T. Kokkonen[1], A. Tesfa[1], M. Tuori[1], K. Hissa[2], E. Jukola[2] and L. Syrjälä-Qvist[1]

[1]Department of Animal Science, University of Helsinki
P.O.B 28, 00014 Helsinki, Finland
[2]Suomen Rehu Ltd.
P.O.B 105, 00241 Helsinki, Finland

(Received 10 May 2000; accepted 4 October 2000)

ABSTRACT

In order to examine the effect of two levels of concentrate and the effect of glucogenic feed (0 l/d (G0) or 1 l/d (G1)) 16 multiparous and 16 primiparous Friesian cows were used in a factorial 2x2 design. The concentrate levels for multiparous cows were 11 kg/d (C11) and 15 kg/d (C15) and for primiparous cows 9 kg/d (C9) and 12 kg/d (C12). The glucogenic feed consisted of propylene glycol, polyols, molasses and niacin. All the animals were offered wilted silage *ad libitum*. The experimental period started from calving and lasted for 12 weeks.

Multiparous cows substituted concentrate for silage when glucogenic feed was not given whereas with glucogenic feed the effect of concentrate on silage dry matter intake (DMI) was minor. Glucogenic feed had a minor effect on milk production at the higher level of concentrate and a negative effect on milk production at the lower level of concentrate. Due to this interaction the milk yield response to the higher level of concentrate was higher with glucogenic feed. The low rumen degradable protein supply in C11G1 was probably the cause of these interactions.

The milk production response of primiparous cows to the higher level of concentrate was low. After peak yield the plasma insulin concentrations were higher with the higher concentrate level. This was accompanied by higher liveweight gain.

In conclusion, the response of multiparous cows to higher concentrate level depended on the supply of rumen degradable protein, whereas the comparable response of primiparous cows was

* Financial support by the Agricultural Research Foundation of August Johannes and Aino Tiura

limited by milk yield potential and the needs of growth. The glucogenic feed showed an ability to increase plasma glucose and decrease the concentrations of ketones.

KEY WORDS: dairy cows, early lactation, grass silage, energy intake, energy metabolism

INTRODUCTION

The feed intake capacity of early lactation cows increases more slowly than their milk yield. Therefore these cows are in negative energy balance for several weeks after parturition. This energy deficit can be partly alleviated by increasing the amount and the proportion of concentrates in feeding. Increased concentrate intake has led to higher milk yield, higher concentration of milk protein and lower concentration of milk fat (Thomas et al., 1986; Aston et al., 1995) with diminishing returns at higher concentrate levels (Østergaard, 1979; Aston et al., 1995). Concentrate substitutes for silage, perhaps with increasing rates at high concentrate rations (Østergaard, 1979; Aston et al., 1995).

Glucogenic potential of diets based on restrictively fermented grass silage is quite low (Huhtanen, 1998). Glucose deficit leads to increased amino acid need for gluconeogenesis, thus limiting the amino acid supply to the mammary gland. Furthermore the glucose deficit increases the risk of ketosis. Subclinical ketosis, which is quite common during early lactation, prevents cows from achieving their potential yield and may decrease fertility (Andersson, 1988). Propylene glycol has been shown to increase blood glucose concentrations and it is widely used in prevention and treatment of ketosis (Emery et al., 1964; Sauer et al., 1973). Niacin has also elevated blood glucose and decreased β-hydroxybutyrate and NEFA (Dufva et al., 1983).

Our hypotheses were: 1. Increased concentrate intake during early lactation increases milk and protein yields and decreases *ad libitum* grass silage intake and lipid mobilization. 2. Glucogenic supplement containing propylene glycol and niacin increases blood glucose concentration and decreases ketone concentrations and lipid mobilization.

MATERIAL AND METHODS

Animals and experimental design

Sixteen primiparous and sixteen multiparous dairy cows (Finnish Friesian) were divided to four treatment groups using a randomized complete block design. Four animal blocks were formed separately for primiparous and multiparous cows taking into account the expected calving date and liveweight for both parities and

the milk yield of previous lactation and previous peak yield for multiparous cows. The animals within the blocks were then allotted to the treatments.

The treatments were 2 x 2 factorially concentrate level and glucogenic liquid feed (0 or 1 l/d; G0 or G1). Concentrate levels were 11 kg/d and 15 kg/d for multiparous cows and 9 kg/d and 12 kg/d for primiparous cows. Thus the treatments were C11G0, C11G1, C15G0 and C15G1 for multiparous cows and C9G0, C9G1, C12G0 and C12G1 for primiparous cows.

The cows were kept in stalls and milked twice daily in a milking parlour. The milk yield was recorded for every milking. Liveweights were measured on two consecutive days three weeks before expected calving date, two weeks after calving and then every two weeks. Condition scoring (scale 1-5, Edmonson et al., 1989) was done by one person through the experiment at the same time as weighing.

Three weeks before calving average condition score of multiparous cows was 3.8 and average liveweight was 678 kg. Cows in C15 group had significantly higher ($P<0.05$) condition scores than cows in C11 group (4.1 vs 3.5). Average condition score of primiparous cows was 3.8 and average liveweight was 591 kg. Average milk yield of multiparous cows during previous lactation (305 d) was 7778 kg energy corrected milk (ECM).

Feeds and feeding

The concentrate consisted of, %: barley 30, sugar beet pulp 25, rapeseed cake 18.75, oats 10, wheat bran 9.25, molasses 5 and minerals 2. The glucogenic liquid feed consisted of, %: propylene glycol 24.4, polyols 25, sugar beet molasses 25, xylose molasses 25 and nicotinamide 0.6.

Three weeks before calving the daily concentrate ration was 2 kg/d and the ration was increased to 3 kg/d by the expected calving date. In order to satisfy the energy requirements, wilted silage was fed restrictively. Energy requirements were calculated according to Finnish standards (Tuori et al., 1996).

The experimental period started from parturition and lasted for 12 weeks. After calving, the daily concentrate amount of 15 kg/d was achieved within 16 days. For two days after parturition the daily increase was 2 kg, for the next two days 1 kg and after that 0.5 kg/d. The concentrate was fed four times a day. Wilted silage was from 1st or 2nd cut and it was given *ad libitum*, allowing 5-10% refusals daily. The silage was fed twice a day. The concentrate and the silage were distributed with automated feeding cars. Feeds and refusals were weighed daily.

Because the crude protein content of the silage was lower than expected, rapeseed meal (RSM) was substituted for 6.67% of the concentrate. Glucogenic feed (1 l, specific weight 1.22 kg/l) was substituted for 1 kg concentrate in G1 groups. It was fed twice daily on top of the concentrate. Mineral supplement was given

100 g/d to multiparous cows and 50 g/d to primiparous cows at lower concentrate level when milk yield exceeded 25 kg/d.

Sampling and chemical analysis

One sample of concentrate and RSM was taken per batch. Silage was sampled weekly. Silage samples from the same silo were pooled although not for a longer period than one month. One sample was taken from the glucogenic feed.

Samples were analysed as described by Kokkonen et al. (2000). The gross energy of glucogenic feed was measured using a bomb calorimeter. Digestibility of silage was determined with four rams. During 21 d digestibility trial, the rams were placed in metabolism crates. Silage was fed at maintenance level. Faeces were collected daily during the last seven days of digestibility trial.

Milk samples were taken on four consecutive milkings starting two weeks after parturition and every two weeks thereafter. Fat, protein, lactose and urea contents of milk were determined as described by Kokkonen et al. (2000) and acetone content of milk with the methods described by Rajamäki and Rauramaa (1985). Milk samples for progesterone determination were taken after milking three times a week starting 10 days after calving until first visible oestrus and stored frozen until determination with radioimmunoassay (RIA) (Laitinen, 1982). When the progesterone concentration exceeded 5 nmol/l at two consecutive samplings, the time of ovulation was estimated to be five days earlier than the rise of concentration. Due to missing samples only 23 animals were included for progesterone analysis.

Blood samples from the jugular vein were taken one week before the expected calving day, and 2, 4 and 6 weeks after calving. Samples were taken to EDTA tubes before afternoon feeding at 13 o'clock. Blood samples for the determination of glucagon and insulin were immediately mixed with trypsin inhibitor (Aprotinin, Sigma A-1153). Plasma was separated by centrifuging and frozen until assay. Blood samples for the determination of β-hydroxybutyrate (BHB) and acetoacetate were treated with 0.6 M perchloric acid and frozen until analyses (Työppönen and Kauppinen, 1980). Glucose was determined enzymatically (Trinder, 1969). Insulin and glucagon were determined with RIA according to a kit procedure (Diagnostic Products Corporation, Coat-A-Count for insulin and Double Antibody Glucagon for glucagon). Non-esterified fatty acids (NEFA) (Wako Chemicals GmbH with the modifications by McCutcheon and Bauman, 1986) and triglycerides (Wahlefeld, 1974) were determined from plasma.

Calculations and statistical analysis

The Finnish AAT - PBV system is a modification of the Nordic AAT - PBV system (Tuori, 1992). AAT measures amino acids (bypass protein and microbial

protein) absorbable from the small intestine. PBV (protein balance value) reflects the abundance of rumen degradable protein for rumen microbial synthesis. Microbial protein synthesis is proportional to the sum of digestible carbohydrates and rumen degradable protein. Effective protein degradability (EPD) value of 85% was used for silage.

A regression curve was fitted to the liveweight data of each animal to calculate liveweight changes. Energy corrected milk yield was calculated according to Sjaunja et al. (1990). Feeding values of concentrate and RSM were calculated using digestibilities from feed tables (Tuori et al., 1996). Feeding values of silages were calculated using digestibilities determined with sheep. Organic matter digestibility was 64% for 1st cut silage and 78% for 2nd cut silage.

For calculation of results (except blood sample data), the experiment was divided to two periods: period 1:1-42 d and period 2:43-84 d. Nutritional composition of feeds was calculated using the feed analyses for each period. Statistical analyses were performed using the GLM procedure of SAS (1989). The results of primiparous and multiparous cows were analysed separately. Milk yield, milk composition, feed intake, energy and nutrient intakes and utilisation, liveweight and liveweight changes and condition score were analysed according to the model:

$Y_{ijk} = \mu + C_i + G_j + B_k + e_{ijk}$ where Y_{ijk} is the observation, μ is the overall mean, C_i is the effect of concentrate level, G_j is the effect of glucogenic feed, B_k is the effect of block and e_{ijk} is the residual effect.

Blood sample data were analysed within sampling time using the model above. If the *prepartum* sample was taken 2 d before calving or later, those animals were not used for *prepartum* blood data analyses. The BHB, acetoacetate, insulin and glucagon data were transformed to logarithms. Effects were considered to be different at $P<0.05$, and tendencies were declared at $P<0.10$.

RESULTS

Feed and diet composition and characteristics

The average chemical composition of the feeds is shown in Table 1. The fermentation quality of silages fed during the experiment was good. However there was considerable variation in chemical composition. Despite RSM supplementation the average crude protein (CP) concentration of diets was as low as 143 g CP/kg DM. The diets contained on average 372 g NDF/kg DM and 200 g ADF/kg DM. The proportion of concentrate was 48 and 56% (DM basis) of the diet of multiparous cows with lower and higher concentrate levels and 52 and 56% of the diet of primiparous cows.

TABLE I

Chemical composition of feeds and feed values

	Silage	Concentrate	RSM	Glucogenic feed
DM, g/kg	277 (233 - 354)	887	879	472
Ash, g/kg DM	79 (71 - 96)	76	78	71
CP, g/kg DM	112 (102 - 125)	160	374	81
EE, g/kg DM	36 (31 - 44)	49	55	
CF, g/kg DM	292 (219 - 328)	99	119	
NDF, g/kg DM	523 (419 - 582)	261	264	
ME[1], MJ/kg DM	10.1 (9.4 - 11.4)	12.5	11.7	19.0[1]
AAT[2], g/kg DM	78 (72 - 87)	109	165	97
PBV[2], g/kg DM	-21 (-44 ... -6)	-15	123	-81
pH	4.03			
Lactic acid, g/kg DM	67 (10 - 107)			
Acetic acid, g/kg DM	15 (4 - 24)			8.4
Propionic acid, g/kg DM	0.6 (0.1 - 1.3)			0.4
Butyric acid, g/kg DM	0.3 (0.1 - 0.7)			
Isobutyric acid, g/kg DM	0.08	1.1		
Sugars, g/kg DM	92 (18 - 221)			465
Soluble N, g/kg N	539 (451 - 604)			
NH_3-N, g/kg N	44 (32 - 55)			

[1] ME = GE × digestibility × ME/DE, where digestibility = 0.95 and ME/DE = 0.84

[2] Finnish AAT – PBV protein evaluation system is a modification of the Nordic AAT – PBV system, see Tuori et al. (1996)

Multiparous cows

There was a significant interaction ($P<0.01$ and $P<0.05$) in silage dry matter intake (DMI) between concentrate level and glucogenic feed in both periods (Tables 2 and 3) and in total DMI ($P<0.05$) during period 1. Without glucogenic feed silage DMI was lower at the higher level of concentrate, but there was only a marginal effect with glucogenic feed. Total DMI was higher ($P<0.01$ and $P<0.001$) in C15 groups in both periods. Difference of total DMI was greater between C15G1 and C11G1 than between the two G0 groups. This interaction was significant ($P<0.05$) during period 1. ME and AAT intakes were higher ($P<0.01$ and $P<0.001$) with the higher concentrate level in both periods. The same kind of interaction ($P<0.10$ or better) was seen in these parameters as in total DMI during period 1. ME intake was higher ($P<0.05$) and PBV was lower ($P<0.05$) with glucogenic feed during period 2.

There was a significant interaction ($P<0.05$) in milk yield between concentrate level and glucogenic feed during period 1. Milk yield was higher with

TABLE 2

Feed intake, milk yield and feed utilisation, multiparous cows (lactation days 1-42)

	Treatments				SEM	Significance		
	C11G0	C11G1	C15G0	C15G1		C	G	C x G
Feed intake, kg DM/d								
silage	10.83	9.36	8.61	9.28	0.313	**		**
concentrate	9.06	9.28	11.58	11.73	0.099	***		
total[1]	19.89	18.64	20.19	21.00	0.361	**		*
ME, MJ/d	225	217	231	245	4.93	**		°
CP, g/d	2840	2595	2963	3035	45.6	***		**
AAT, g/d	1883	1763	1965	2028	35.7	**		*
PBV, g/d	-259	-305	-250	-287	49.8			
CF, g/d	3993	3543	3642	3845	119.7			*
NDF, g/d	8017	7178	7683	7869	217.3			*
ADF, g/d	4346	3861	4023	4217	123.5			*
Milk and milk component yield, kg/d								
milk	36.73	31.69	36.62	38.00	1.08	*		*
ECM	35.55	31.52	34.55	36.45	1.18			*
fat yield	1.38	1.24	1.28	1.39	0.075			
protein yield	1.16	1.05	1.21	1.22	0.041	*		
lactose yield	1.80	1.53	1.79	1.88	0.064	*		*
Milk composition, g/kg								
fat	38.0	38.8	34.9	37.0	2.27			
protein	31.7	33.3	33.1	32.1	0.895			
lactose	49.0	48.0	48.8	49.5	1.06			
urea, mg/100 ml	14.3	17.0	18.2	17.6	1.87			
Feed utilisation and liveweight change								
LWC, kg/d	0.34	-0.14	-1.28	-0.88	0.560	°		
condition score	3.0	2.9	3.2	3.4	0.17	°		
k_l[2]	0.74	0.65	0.56	0.58	0.053	*		
milk protein/CP, g/g	0.41	0.40	0.41	0.40	0.014			

[1] includes mineral supplement in lower concentrate level

[2] k_l = ECM × 3.14 / (ME intake - ME allowance for maintenance - ME of LWC x LWC), where ME of LWC is 28 MJ/kg LW loss and 34 MJ/kg LW gain and ME allowance for maintenance is calculated according to MAFF (1975)

ECM = energy corrected milk yield; k_l = ME utilisation for milk production

° P<0.10; * P<0.05; ** P<0.01; *** P<0.001; C = concentrate, GF = glucogenic feed

TABLE 3

Feed intake, milk yield and feed utilisation, multiparous cows (lactation days 43 - 84)

	Treatments				SEM	Significance		
	C11G0	C11G1	C15G0	C15G1		C	G	C x G
Feed intake, kg DM/d								
silage	10.74	10.36	9.20	10.82	0.403			*
concentrate	9.60	9.64	13.04	13.03	0.042	***		
total[1]	20.34	20.00	22.24	23.85	0.043	***	*	
ME, MJ/d	231	237	263	288	5.28	***	*	
CP, g/d	2914	2781	3322	3419	45.5	***		*
AAT, g/d	1946	1927	2237	2362	39.3	***		
PBV, g/d	-284	-391	-333	-452	38.9		*	
CF, g/d	3918	3581	3645	3927	143			°
NDF, g/d	7977	7331	7794	8274	248			*
ADF, g/d	4304	3945	4071	4370	150			°
Milk and milk component yield, kg/d								
milk	39.00	34.27	38.51	38.95	1.91			
ECM	35.14	32.57	37.06	35.28	1.46			
fat yield	1.30	1.24	1.41	1.27	0.070			
protein yield	1.14	1.09	1.25	1.18	0.042	*		
lactose yield	1.94	1.68	1.90	1.98	0.099			
Milk composition, g/kg								
fat	33.6	35.9	36.8	32.8	1.91			
protein	29.3	31.8	32.8	30.4	0.672			**
lactose	49.8	49.0	49.4	50.8	0.932			
urea, mg/100 ml	19.8	15.2	17.2	17.3	1.46			
Feed utilisation and liveweight change								
LWC, kg/d	-0.06	0.54	0.34	0.28	0.229			
condition score	2.9	3.0	3.2	3.3	0.13	°		
k_l[2]	0.65	0.66	0.63	0.52	0.029	*	°	°
milk protein/CP, g/g	0.39	0.39	0.38	0.34	0.017			

[1] includes mineral supplement in lower concentrate level

[2] k_l = ECM x 3.14 / (ME intake – ME allowance for maintenance – ME of LWC x LWC), where ME of LWC is 28 MJ/kg LW loss and 34 MJ/kg LW gain and ME allowance for maintenance is calculated according to MAFF (1975)

ECM = energy corrected milk yield; k_l = ME utilisation for milk production

° P<0.10; * P<0.05; ** P<0.01; *** P<0.001

glucogenic feed at the higher concentrate level whereas the opposite was true at the lower concentrate level. Milk, protein and lactose yields were higher (P<0.05) in C15 groups during period 1. Only protein yield was higher (P<0.05) at the higher level of concentrate during period 2. There were significant (P<0.05 or better) interactions between concentrate level and glucogenic feed in ECM and lactose yields during period 1 and in protein concentration of milk during period 2. ME utilisation for milk production (k_l) was higher (P<0.05) in C11 groups in both periods.

Plasma glucagon concentrations were higher (P<0.10 or better) in C15 groups in all *post partum* samplings (Table 6). Glucose concentration tended to be higher (P<0.10) with glucogenic feed at 2 and 6 weeks *post partum*. At the same time BHB and acetoacetate concentrations were lower (P<0.10 or better) with glucogenic feed.

According to progesterone concentrations, the time of first ovulation was 37, 32, 12 and 24 days from parturition in groups C11G0, C11G1, C15G0 and C15G1. The number of open days was 79, 108, 89 and 74. There was no difference in incidences of diseases (data not shown).

Primiparous cows

Neither daily concentrate ration nor glucogenic feed had a significant effect on silage DM intake (Tables 4 and 5). Total DM intake, ME intake and CP and AAT intakes were higher (P<0.01 or better) in C12 groups during both periods.

There were no significant (P<0.05) effects on milk yield or milk composition. Liveweight gain tended to be higher (P<0.10) with the higher concentrate ration during period 2. Energy (P<0.10 or better) and protein (g milk protein/g CP) (P<0.05 or better) utilisation were lower in both periods in C12 groups. Protein utilisation tended to be higher (P<0.10) with glucogenic feed in both periods.

Plasma glucose concentrations were higher (P<0.05) in C12 groups 4 weeks *post partum*, and BHB and acetoacetate concentrations were lower (P<0.01) 6 weeks *post partum* (Table 7). Insulin concentrations tended to be higher (P<0.10) 6 weeks *post partum* in C12 groups. Triglyceride concentrations 2 weeks *post partum* were lower (P<0.05) with glucogenic feed, and BHB and glucagon concentration tended to be lower (P<0.10) 6 weeks after calving with glucogenic feed.

According to progesterone concentrations, the time of first ovulation was 43, 31, 33 and 36 days from parturition in groups C9G0, C9G1, C12G0 and C12G1. The number of open days was 129, 86, 95 and 90. The only clinically ketotic cow in the experiment was in group C9G0.

TABLE 4

Feed intake, milk yield and feed utilisation, primiparous cows (lactation days 1-42)

	Treatments				SEM	Significance		
	C9G0	C9G1	C12G0	C12G1		C	G	C x G
Feed intake, kg DM/d								
silage	7.46	6.17	7.58	6.73	0.736			
concentrate	7.47	7.66	9.66	9.89	0.060	***	**	
total[1]	14.93	13.83	17.24	16.62	0.741	**		
ME, MJ/d	172	166	202	202	7.61	**		
CP, g/d	2144	1948	2501	2362	94.1	**		
AAT, g/d	1438	1341	1700	1648	60.9	**		
PBV, g/d	-221	-256	-287	-338	33.5	°		
CF, g/d	2721	2344	2895	2604	224.6			
NDF, g/d	5721	4898	6225	5592	418.8			
ADF, g/d	2984	2580	3204	2884	242.1			
Milk and milk component yield, kg/d								
milk	24.94	27.94	27.35	27.04	1.17			
ECM	24.90	26.10	25.85	27.04	0.900			
fat yield	0.98	0.98	0.95	1.05	0.043			
protein yield	0.83	0.86	0.87	0.88	0.034			
lactose yield	1.23	1.40	1.39	1.37	0.063			
Milk composition, g/kg								
fat	39.2	35.3	35.0	39.4	1.98			°
protein	33.2	30.8	32.1	32.7	0.839			
lactose	49.1	50.0	50.6	50.7	0.743			
urea, mg/100 ml	16.2	13.2	15.1	13.2	2.67			
Feed utilisation and liveweight change								
LWC, kg/d	-0.45	-0.66	-0.55	-0.13	0.191			
condition score	3.5	3.1	3.2	3.2	0.18			
k_l[2]	0.65	0.64	0.50	0.61	0.045	°		
milk protein/CP, g/g	0.39	0.44	0.35	0.37	0.018	*	°	

[1] includes mineral supplement in lower concentrate level

[2] k_l = ECM x 3.14 / (ME intake – ME allowance for maintenance – ME of LWC x LWC), where ME of LWC is 28 MJ/kg LW loss and 34 MJ/kg LW gain and ME allowance for maintenance is calculated according to MAFF (1975)

ECM = energy corrected milk yield; k_l = ME utilisation for milk production

° P<0.10; * P<0.05; ** P<0.01; *** P<0.001

TABLE 5

Feed intake, milk yield and feed utilisation, primiparous cows (lactation days 43-84)

	Treatments				SEM	Significance		
	C9G0	C9G1	C12G0	C12G1		C	G	C x G
Feed intake, kg DM/d								
silage	8.54	7.26	8.79	8.85	0.791			
concentrate	7.78	7.95	10.49	10.59	0.069	***	°	
total[1]	16.32	15.21	19.28	19.43	0.826	**		
ME, MJ/d	184	177	220	228	9.86	**		
CP, g/d	2342	2133	2866	2796	96.8	***		
AAT, g/d	1543	1436	1872	1877	75.4	**		
PBV, g/d	-194	-225	-199	-283	49.4			
CF, g/d	3302	2932	3609	3513	236.6	°		
NDF, g/d	6588	5841	7399	7148	419.3	*		
ADF, g/d	3600	3201	3971	3873	247.1	°		
Milk and milk component yield, kg/d								
milk	26.78	29.42	29.40	29.57	1.38			
ECM	26.76	27.59	27.07	28.11	0.965			
fat yield	1.06	1.05	1.01	1.04	0.038			
protein yield	0.87	0.89	0.88	0.94	0.033			
lactose yield	1.32	1.47	1.48	1.53	0.074			
Milk composition, g/kg								
fat	39.9	36.0	34.5	35.5	1.68			
protein	32.4	30.5	30.0	31.7	0.822			°
lactose	49.3	50.1	50.3	51.9	0.729	°		
urea, mg/100 ml	19.4	17.7	20.3	18.3	2.47			
Feed utilisation and liveweight change								
LWC, kg/d	0.34	0.18	0.48	0.61	0.129	°		
condition score	3.6	3.1	3.3	3.3	0.18			
MJ/kg ECM	4.2	4.2	5.4	5.2	0.40	*		
k_l[2]	0.74	0.78	0.58	0.62	0.061	*		
milk protein/CP, g/g	0.37	0.42	0.31	0.34	0.019	**	°	

[1] includes mineral supplement in lower concentrate level

[2] k_l = ECM x 3.14 / (ME intake - ME allowance for maintenance - ME of LWC x LWC), where ME of LWC is 28 MJ/kg LW loss and 34 MJ/kg LW gain and ME allowance for maintenance is calculated according to MAFF (1975)

ECM = energy corrected milk yield; k_l = ME utilisation for milk production

° P<0.10; * P<0.05; ** P<0.01; *** P<0.001

TABLE 6

Blood composition, multiparous cows

	Treatments				SE	Significance		
	C11G0	C11G1	C15G0	C15G1		C	G	C x G
1 week[1]								
glucose, mg/100 ml	61.6	58.8	66.7	62.9	3.49	*		
Nefa, mEq/l	0.12	0.19	0.22	0.20	0.095			
BHB, mmol/l	0.34	0.36	0.31	0.32	0.047			
insulin µIU/ml	9.9	12.7	11.1	12.8	4.24			
triglycerides, mmol/l	0.42	0.34	0.42	0.50	0.087			
2 weeks[2]								
glucose, mg/100 ml	46.0	56.6	56.2	61.6	7.79		°	
Nefa, mEq/l	0.50	0.41	0.47	0.67	0.27			
BHB, mmol/l	1.11	0.49	1.01	0.39	0.66		°	
insulin µIU/ml	7.1	8.7	7.2	7.8	2.76			
triglycerides, mmol/l	0.30	0.18	0.24	0.27	0.097			
glucagon, pg/ml	66.3	49.9	82.5	84.9	20.6	°		
acetoacetate, mmol/l	0.19	0.03	0.12	0.00	0.18		°	
4 weeks								
glucose, mg/100 ml	54.3	61.5	58.8	66.3	6.79			
Nefa, mEq/l	0.31	0.33	0.38	0.36	0.18			
BHB, mmol/l	0.97	0.73	0.97	0.75	0.37			
insulin µIU/ml	8.7	10.0	9.4	9.8	2.87			
triglycerides, mmol/l	0.20	0.26	0.20	0.30	0.094			
glucagon, pg/ml	78.1	51.5	99.4	83.1	21.8	*	°	
acetoacetate, mmol/l	0.11	0.08	0.13	0.06	0.12			
6 weeks								
glucose, mg/100 ml	61.3	66.5	60.5	72.5	8.82		°	
Nefa, mEq/l	0.28	0.25	0.32	0.27	0.13			
BHB, mmol/l	1.69	0.52	0.97	0.49	0.42		**	
insulin µIU/ml	8.1	11.6	9.5	12.7	3.35		°	
triglycerides, mmol/l	0.23	0.19	0.20	0.18	0.049			
glucagon, pg/ml	76.3	58.6	96.7	91.6	23.4	*		
acetoacetate, mmol/l	0.29	0.05	0.14	0.03	0.10		°	

[1] C11G0 and C11G1: n = 3, C15G0 and C15G1: n = 4

[2] C15G1: n = 3, C11G0, C11G1 and C15G0: n = 4

° * as in Table 5

TABLE 7

Blood composition, primiparous cows

	Treatments				SE	Significance		
	C9G0	C9G1	C12G0	C12G1		C	G	C x G
-1 week[1]								
glucose, mg/100 ml	62.2	70.3	61.9	68.9	4.76		°	
Nefa, mEq/l	0.25	0.25	0.19	0.21	0.17			
BHB, mmol/l	0.34	0.20	0.32	0.28	0.056		*	
insulin µIU/ml	11.5	15.9	15.4	11.1	3.81			
triglyserides, mmol/l	0.44	0.44	0.39	0.43	0.087			
2 weeks								
glucose, mg/100 ml	62.4	62.0	66.9	64.5	7.49			
Nefa, mEq/l	0.49	0.32	0.40	0.46	0.31			
BHB, mmol/l	0.86	0.61	0.37	0.59	0.52			
insulin µIU/ml	11.5	9.4	9.9	9.3	3.87			
triglyserides, mmol/l	0.33	0.18	0.23	0.16	0.077		*	
glucagon, pg/ml	80.1	52.8	66.7	66.6	44.1			
acetoacetate, mmol/l	0.13	0.06	0.01	0.04	0.13			
4 weeks								
glucose, mg/100 ml	59.9	63.9	68.6	72.9	6.40	*		
Nefa, mEq/l	0.33	0.22	0.25	0.25	0.18			
BHB, mmol/l	1.09	0.66	0.71	0.39	0.60			
insulin µIU/ml	8.4	11.1	14.6	11.4	5.12			
triglyserides, mmol/l	0.21	0.26	0.20	0.19	0.064			
glucagon, pg/ml	96.0	61.0	76.3	68.7	30.9			
acetoacetate, mmol/l	0.20	0.08	0.05	0.01	0.18			
6 weeks								
glucose, mg/100 ml	60.1	67.3	68.1	71.3	7.39			
Nefa, mEq/l	0.26	0.27	0.26	0.22	0.18			
BHB, mmol/l	2.01	0.64	0.42	0.34	0.89	**	°	
insulin µIU/ml	6.8	9.7	11.0	13.9	4.59	°		
triglyserides, mmol/l	0.22	0.29	0.32	0.21	0.087			°
glucagon, pg/ml	100.0	71.2	91.3	77.9	21.6		°	
acetoacetate, mmol/l	0.39	0.05	0.00	0.00	0.25	**		

[1] C9G1: n = 2, C12G0 and C12G1: n = 3, C9G0: n = 4

° * as in Table 5

DISCUSSION

Multiparous cows

Silage DMI usually decreases with increased concentrate ration and it has been proposed that substitution ratio increases with higher concentrate levels (Østergaard, 1979). The substitution ratio between C11G0 and C15G0 in period 1 (Table 8) was slightly higher than -0.48 kg DM/kg DM concentrate for early lactation cows reported by Aston et al. (1995) and -0.61 kg DM/kg DM concentrate for high concentrate levels in mid lactation reported by Huhtanen (1998).

The addition of glucogenic feed to diet altered the response of cows to concentrate. The substitution ratios between C11G1 and C15G1 were close to zero. Since glucogenic feed was a mixture of propylene glycol, polyols, molasses and nicotinamide, it is difficult to say, what is the effect of a separate component of this

TABLE 8

Responses to concentrate supplementation

	Responses between	
	C11G0 and C15G0	C11G1 and C15G1
Multiparous cows, period 1		
substitution ratio, kg silage DM/kg concentrate DM	-0.88	-0.03
ECM yield response, kg/increased kg concentrate DM	-0.40	+2.01
Multiparous cows, period 2		
substitution ratio, kg silage DM/kg concentrate DM	-0.45	+0.14
ECM yield response, kg/increased kg concentrate DM	+0.56	+0.80
	C9G0 and C12G0	C9G1 and C12G1
Primiparous cows, period 1		
substitution ratio, kg silage DM/kg concentrate DM	+0.05	+0.25
ECM yield response, kg/increased kg concentrate DM	+0.43	+0.42
Primiparous cows, period 2		
substitution ratio, kg silage DM/kg concentrate DM	+0.09	+0.60
ECM yield response, kg/increased kg concentrate DM	+0.11	+0.20

mixture on feed intake. In earlier experiments propylene glycol (up to about 500 g/d) (Fisher et al., 1973; Jans and Münger, 1992) or niacin (12 g/d) (e.g. Dufva et al., 1983) had no significant effect on feed intake. In our experiment, the intakes of propylene glycol and nicotinamide were 244 ml/d (about 300 g/d) and 6 ml/d (7.3 g/d).

The milk yield response between C11G0 and C15G0 was negative during period 1 (Table 8). It must be noted, however, that the substitution ratio between these groups was especially high during this period and thus the increase of ME intake was small. The response during period 2 is in line with Huhtanen (1998), who reviewed some Finnish experiments conducted after peak yield with average concentrate levels 6.72 kg DM/d and 11.57 kg DM/d and with average response of 0.43 kg ECM per increased kg concentrate DM, and it is much higher than the marginal yield 0.05 kg/d reported by Østergaard (1979) with a concentrate ration of 11.7 kg DM/d in early lactation cows. However, Aston et al. (1995) reported much higher milk yield responses with an average response of 1.02 kg ECM per increased kg concentrate DM with concentrate rations 6, 9 and 12 kg DM/d.

The milk yield response to concentrate feeding was higher with glucogenic feed than without it. High response to concentrate was due to low milk yield of C11G1 whereas C11G0 had as high milk yield as both high concentrate groups. Using previous lactation 305 d yield as a covariate revealed that this was not due to superior milk yield potential of cows in the C11G0. Contrasting some earlier reports of increased milk production with propylene glycol (Emery et al., 1964; Fisher et al., 1973) or niacin (e.g. Dufva et al., 1983), the glucogenic feed with both these ingredients could not increase milk production and in fact C11G1 had the lowest milk production. In line with this Jans and Münger (1992) (max 150 g/d propylene glycol) or Burhans and Bell (1998) did not observe an increase in milk production of early lactation cows with propylene glycol.

Milk urea concentrations remained under 20 mg/100 ml during the whole experiment. Though milk urea concentrations are lower at the early stage of lactation than in other stages (Gustafsson, 1993), the low milk urea concentrations were partly due to the low CP content of silage, which was not totally compensated by inclusion of RSM to the diets. It seems that protein supply, especially the supply of rumen degradable protein, was the limiting factor in C11G1 because 1 kg concentrate, which had close to zero PBV content, was replaced by low PBV glucogenic feed. PBV values of this group were low and PBV was near -20 g/kg DM during period 2. Therefore rumen microbial protein synthesis and true AAT supply may have been diminished (Table 9). Low rumen degradable protein supply seemed not to limit silage intake capacity of C11G1 during period 2, but the extra energy partitioned towards liveweight gain.

Milk protein content and protein yield have increased in several experiments (Gordon et al., 1984; Thomas et al., 1986; Aston et al., 1995) with increasing

concentrate as a result of higher energy intake. However, the biggest increases in protein content have been achieved between low levels of concentrate (3 to 6 kg DM/d) (Aston et al., 1995). This may explain the fact that concentrate level had no effect on milk protein content in our experiment with high concentrate levels.

Energy utilisation was lower in C15 groups than in C11 groups, which reflects the diminishing returns with increased concentrate. In contrast to earlier reports (Østergaard, 1979; Gordon, 1984; Aston et al., 1995), liveweight loss seemed to be greater at higher concentrate level, although NEFA concentration of plasma gives no support to LWC data. It is possible that the greater liveweight loss was due to greater fat deposits at the beginning of lactation. Condition score of C15 group was higher than that of C11 group three weeks before calving.

Glucagon may stimulate glycogenolysis and gluconeogenesis in liver and it may increase the usage of amino acids to gluconeogenesis (Brockman and Laarveld, 1986). There was a strong positive correlation between ECM and plasma glucagon concentration (means of first six lactation weeks) ($r=0.67$, $P=0.005$), which reflects the dependence of multiparous cows in early lactation on gluconeogenesis. Plasma glucagon concentrations were higher at the higher level of concentrate in our experiment. Glucose concentrations were not significantly affected but on average they were higher with higher concentrate level. The results reported by Aiello et al. (1984) give some support to increased gluconeogenesis at the higher level of concentrate. They observed higher rates of gluconeogenesis with liver samples taken from cows having high concentrate diet than in samples taken from cows having low concentrate diet. Furthermore, there is some evidence that the capacity of liver to convert propionate to glucose is higher with increased energy intakes (Overton, 1998).

Propylene glycol and niacin are both components capable of decreasing blood ketone concentrations (Sauer et al., 1973; Dufva et al., 1983; Jans and Münger, 1992) and propylene glycol has been shown to increase blood glucose concentrations (Emery et al., 1964). This trend is seen in our experiment. However, it must be noted that using the milk acetone threshold (> 0.40 mmol/l) presented by Andersson (1988) multiparous cows had only three hyperketonaemic milk samples: one each in groups C11G0, C15G0 and C15G1.

Primiparous cows

As in older cows, the inclusion of glucogenic feed altered the response of cows to the higher level of concentrate. The increase of silage DM intake with increased concentrate was higher between C9G1 and C12G1 than between C9G0 and C12G0 during both periods (Table 8). Nevertheless, all substitution ratios were positive. Positive substitution ratio (i. e. silage intake increases with concentrate intake) is an exception (Thomas, 1987). In contrast to our results Østergaard (1979)

observed that substitution ratio was more negative with primiparous cows than with multiparous cows.

Differing from multiparous cows C9G0 had the lowest milk yield although without significant differences. C9G1 had as high a milk yield as the two higher concentrate groups. The differences between the groups in ECM were smaller. The average response of ECM yield to increased concentrate (Table 8) was low but not as low as in Østergaard's (1979) experiment, where the marginal yield was negative when heifers were fed 11.7 kg DM/d concentrate. At lower concentrate levels heifers have had better responses to increased concentrate (Phipps et al., 1987; Coulon et al., 1994). In experiment reported by Phipps et al. (1987) the response was 0.62 kg milk per increased kg concentrate DM.

Though CP and AAT intakes were higher in C12 than in C9, milk yield response remained low. Protein or amino acid supply (Table 9) was probably not the primary limiting factor for milk production. In this respect there seems to be a difference between primiparous and multiparous cows. The lower response of heifers to the higher level of concentrate compared to older cows probably reflects a difference in milk yield potential. Primiparous cows have a rather high priority for tissue gain and they may not therefore mobilize adipose tissues as efficiently as older cows (Strickland and Broster, 1981).

TABLE 9

PBV corrected AAT intakes

	C11G0	C11G1	C15G0	C15G1
Multiparous cows, period 1				
PBV, g/kg DM	-13.0	-16.4	-12.4	-13.7
true AAT intake, g/d[1]	1729	1582	1816	1857
Multiparous cows, period 2				
PBV, g/kg DM	-14.0	-19.6	-15.0	-19.0
true AAT intake, g/d	1777	1694	2039	2093
	C9G0	C9G1	C12G0	C12G1
Primiparous cows, period 1				
PBV, g/kg DM	-14.8	-18.5	-16.6	-20.3
true AAT intake, g/d	1307	1189	1529	1447
Primiparous cows, period 2				
PBV, g/kg DM	-11.9	-14.8	-10.3	-14.6
true AAT intake, g/d	1428	1302	1754	1709

[1] true AAT intake (g/d) = AAT intake (g/d) + 0.595 × PBV (g) (Tuori et al., 1996), assuming the proportion of amino acids in microbial protein = 0.70 and the digestibility of microbial protein = 0.85

There were positive correlations between ECM and NEFA and ECM and BHB in multiparous cows (r=0.42, P=0.11; r=0.62, P=0.01) but not in primiparous cows (r=0.09, P=0.75; r=0.01, P=0.97). This suggests smaller role of tissue deposits for milk production in primiparous cows.

It seems that the heifers in our experiment were able to reach their maximal yield with 9 kg/d concentrate. This seems to indicate that some physiological factor, perhaps the capacity of secretory cells in the mammary gland may have limited milk production. Furthermore, there was no positive correlation between glucagon and milk yield in primiparous cows.

Plasma glucose concentrations in C9G0 at weeks 4 and 6 were lower than in other groups suggesting that glucose supply may have limited milk yield in this group. Moreover, using the threshold of milk acetone (> 0.40 mmol/l) presented by Andersson (1988), the only ketotic animal in the experiment was in this group.

Plasma glucose seemed to be higher and ketone concentrations seemed to be lower at the higher level of concentrate. With glucogenic feed this trend can be seen too.

The extra energy from concentrate was partitioned towards liveweight gain during period 2. This is in line with earlier experiments (Østergaard, 1979; Phipps et al., 1987; Coulon et al., 1994). In line with liveweight data plasma insulin was higher at the higher level of concentrate 6 weeks after calving, C12G1 having the highest concentrations and C9G1 having the lowest concentrations. As in older cows, the energy utilisation for milk production was lower at the higher level of concentrate.

CONCLUSIONS

Due to the experimental design even fairly large differences (e.g. milk yield difference of 3 kg/d) proved to be statistically not significant. This design was dictated by our desire to study the whole period of early lactation, including the first week after parturition, which is often neglected in experiments resembling that of ours.

In both parity groups, maximal milk yield during the experiment could be achieved even with one of the treatments with lower concentrate level. However, there was a difference in response to glucogenic feed between parities. In older cows, glucogenic feed had a negative effect on milk production at the lower concentrate level, suggesting that with low CP grass silage rumen degradable protein was the factor limiting milk yield instead of supply of glucogenic substrate. Due to lower production potential of primiparous cows, their amino acid need for milk production could be satisfied even with lower level of concentrate with glucogenic feed.

Plasma glucose concentrations of multiparous cows were higher and the concentrations of ketones were lower with glucogenic feed. In heifers, after peak yield, the plasma insulin concentrations were higher with the higher concentrate level. This was accompanied by partitioning extra nutrients towards tissue gain.

ACKNOWLEDGEMENTS

The authors wish to thank M. Sc. Sakari Alasuutari, Mr. Jorma Tossavainen and the staff of Suitia research farm for conducting the trial and DVM Juha Kallio for the interpretation of progesterone analyses.

REFERENCES

Aiello R.J., Kenna T.M., Herbein J.H., 1984. Hepatic gluconeogenic and ketogenic interrelationships in the lactating cow. J. Dairy Sci. 67, 1707-1715

Andersson L., 1988. Subclinical ketosis in dairy cows. Vet. Clin. North Amer. Food Anim. Prac. 4, 233-251

Aston K., Sutton J.D., Fisher W.J., 1995. Milk production from grass silage diets: strategies for concentrate allocation. Anim. Sci. 61, 465-480

Brockman R.P., Laarveld B., 1986. Hormonal regulation of metabolism in ruminants; a review. Livest. Prod. Sci. 14, 313-334

Burhans W.S., Bell A.W., 1998. Feeding the transition cow. In: Proceedings of 1998 Cornell Nutrition Conference for Feed Manufacturers, pp. 247-258

Coulon J.B., D'Hour P., Garel J.P., Petit M., 1994. Level and pattern of winter concentrate allocation in dairy cows: results in first lactation cows. Anim. Prod. 59, 11-20

Dufva G.S., Bartley E.E., Dayton A.D., Riddell D.O., 1983. Effect of niacin supplementation on milk production and ketosis of dairy cattle. J. Dairy Sci. 66, 2329-2336

Edmonson A.J., Lean I.J., Weaver L.D., Farver T., Webster G., 1989. A body condition chart of Holstein dairy cows. J. Dairy Sci. 72, 68-78

Emery R.S., Burg N., Brown L.D., Blank S.N., 1964. Detection, occurrence and prophylactic treatment of borderline ketosis with propylene glycol feeding. J. Dairy Sci. 47, 1074-1079

Fisher L.J., Erfle J.D., Lodge G.A., Sauer F.D., 1973. Effects of propylene glycol or glycerol supplementation of the diet of dairy cows on the feed intake, milk yield and composition, and incidence of ketosis. Can. J. Anim. Sci. 53, 289-296

Gordon F.J., 1984. The effect of level of concentrate supplementation given with grass silage during the winter on the total lactation performance of autumn-calving cows. J. Agr. Sci. 102, 163-179

Gustafsson A.H., 1993. Acetone and urea concentrations in milk as indicators of the nutritional status and the composition of the diet of dairy cows. Academic Dissertation. Report 222, Swedish University of Agricultural Science, Department of Animal Nutrition and Management

Huhtanen P., 1998. Supply of nutrients and productive responses in dairy cows given diets based on restrictively fermented silage. Agr. Food Sci. Finland 7, 219-250

Jans F., Münger A., 1992. Effet du propylèneglycol comme agent de prevention de l'acétonémie durant la phase de démarrage chez la vache laitière. Revue Suisse Agr. 24, 237-242

Kokkonen T., Tuori M., Leivonen V., Syrjälä-Qvist L., 2000. Effect of silage dry matter content and rapeseed meal supplementation on dairy cows. 1. Milk production and feed utilisation. Anim. Feed Sci. Tech. 84, 213-228

Laitinen J., 1982. Evaluation of defatted and whole milk progesterone radioimmunoassays (in Finnish). Suomen eläinlääkärilehti 88, 501-505

MAFF, 1975. Energy Allowance and Feeding System for Ruminants. Tech. Bull. 33. Her Majesty's Stationery Office, London

McCutcheon S.N., Bauman, D.E., 1986. Effect of chronic growth hormone treatment on responses to epinephrine and thyrotropin releasing hormone in lactating cow. J. Dairy Sci. 69, 44-51

Østergaard V., 1979. Stategies for concentrate feeding to attain optimum feeding level in high yielding dairy cows. Beretning fra Statens Husdyrbrugsforsøg, No. 482

Overton T., 1998. Substrate utilisation for hepatic gluconeogenesis in the transition dairy cow. In: Proceedings of 1998 Cornell Nutrition Conference for Feed Manufacturers, pp. 237-246

Phipps R.H., Weller R.F., Bines J.A., 1987. The influence of forage quality and concentrate level on dry matter intake and milk production of British Friesian heifers. Grass Forage Sci. 42, 49-58

Rajamäki S., Rauramaa A., 1985. The determination of acetoacetate and 3-hydroxybutyrate in milk. Finn. J. Dairy Sci. 43, 9

SAS, 1989. SAS/STAT Users Guide, Version 6. Vol. 2. 4th Edition. SAS Institute Inc., Cary, NC (USA)

Sauer F.D., Erfle J.D., Fisher L.J., 1973. Propylene glycol and glycerol as a feed additive for lactating dairy cows: an evaluation of blood metabolite parameters. Can. J. Anim. Sci. 53, 265-271

Sjaunja L.O., Baerve L., Junkkarinen L., Pedersen J., Setälä J., 1990. A Nordic proposal for an energy corrected milk (ECM) formula. In: 27th Session International Committee of Recording and Productivity of Milk Animal, Paris (France), pp. 156-157

Strickland M.J., Broster, W.H., 1981. The effect of different levels of nutrition at two stages of the lactation on milk production and live-weight change in Friesian cows and heifers. J. Agr. Sci. 96, 677-690

Thomas C., 1987. Factors affecting substitution rates in dairy cows on silage based rations. In: W. Haresign, D.J.A. Cole (Editors). Recent Advances in Animal Nutrition. Butterworths, London, pp. 205-218

Thomas C., Aston K., Daley S.R., Bass J., 1986. Milk production from silage. 4. The effect of the composition of the supplement. Anim. Prod. 42, 315-325

Trinder P., 1969. Determination of glucose in blood using glucoseoxidase with an alternative oxygen acceptor. Ann. Clin. Biochem. 6, 24-27

Tuori M., Kaustell K., Valaja J., Aimonen E., Saarisalo E., Huhtanen P., 1996. Feed tables and feeding recommendations. 2nd Edition. Helsinki (Finland)

Työppönen J., Kauppinen K., 1980. The stability and automatic determination of ketone bodies in blood samples taken in field conditions. Acta Vet. Scand. 21, 55-61

Wahlefeld A.W., 1974. Triglycerides. Determination after enzymatic hydrolysis. In: H.U. Bergmeyer, (Editor). Methods of Enzymatic Analysis. Vol. 4. 2nd English Edition. Academic Press, New York

STRESZCZENIE

Wpływ ilości paszy treściwej oraz paszy glukogennej podawanych we wczesnym okresie laktacji na pobranie paszy, produkcję mleka oraz przemianę energii u krów mlecznych i jałówek

W doświadczeniu, o układzie czynnikowym 2 x 2, przeprowadzonym na krowach fryzach, 16 wieloródkach i 16 pierwiastkach, porównano dwa poziomy paszy treściwej oraz wpływ dodatku paszy glukogennej (0 l; G0 lub 1 l/d G1) na wyniki produkcyjne. Ilość paszy treściwej dla wieloródek wynosiła 11 kg/d (C11) lub 15 kg/d (C15), dla pierwiastek 9 kg/d (C9) lub 12 kg/d (C12). Pasza glukogenna składała się z glikolu propylenowego, polialkoholi, melasy i niacyny. Ponadto wszystkie zwierzęta otrzymywały do woli podwiędniętą kiszonkę. Doświadczenie trwało 12 tygodni, rozpoczynając od wycielenia krów.

Przy podawaniu paszy głukogennej krowom wieloródkom stwierdzono niewielki wpływ dawki na pobranie s.m. kiszonki, podczas gdy bez tego dodatku krowy zjadały więcej s.m. paszy treściwej zamiast s.m. kiszonki. Pasza glukogenna miała też niewielki wpływ na produkcję mleka przy większych dawkach paszy treściwej, natomiast ujemny – przy mniejszej dawce. W wyniku tej interakcji reakcja wydajności mleka na większą dawkę paszy treściwej była większa przy dodatku paszy glukogennej. Przyczyną tych interakcji była prawdopodobnie mała ilość białka rozkładanego w żwaczu przy skarmianiu dawki C11 G1.

U pierwiastek reakcja, wyrażona ilością produkowanego mleka na większą dawkę paszy treściwej, była mała. Po szczycie wydajności mleka stężenie insuliny w plazmie krwi, podobnie jak i przyrosty dzienne były większe przy większej dawce paszy treściwej.

W podsumowaniu stwierdzono, że stopień reakcji wieloródek na wysokie dawki paszy treściwej zależy od podaży ilości rozkładanego w żwaczu białka, podczas gdy u pierwiastek jest ograniczona zdolnością produkcji mleka i zapotrzebowaniem na wzrost. Dodatek paszy glukogennej zwiększa poziom glukozy, a obniża stężenie ciał ketonowych w plazmie krwi.