

Effect of milk replacer feeding frequency and level on concentrate intake and rearing performance of calves

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ABSTRACT

Fifty-four Black-and-White bull calves divided into 5 groups of 10-11 animals aged from 6-8 to 120 days, were used to study the effect of liquid feeding frequency and the amount of milk replacer on concentrate intake and rearing performance. The milk replacer contained: dried skim milk, whey, buttermilk, and processed soya protein. The liquid feed was fed from 7 to 56 days of age once (S), twice (D) or three (T) times a day at limited feeding (L and L_{1/2}), or feeding to appetite (V). The intake of milk replacer per calf in the experimental period was: 54 kg (groups SL, DL, TL), 27 kg (group SL_{1/2}) or 87 kg of dried milk replacer (group TV). In groups SL, DL, TL, SL_{1/2} and TV, the liquid feed contained 155.5 g of solid milk replacer per kg of solution, and in group SV, 262 g of milk replacer per kg solution. All of the calves received concentrate to appetite and meadow hay (0.1-0.3 kg/day). It was found that at a similar intake of milk replacer (51 kg DM/calf), and once-daily liquid feeding compared with feeding twice and three times a day, daily weight gains were lower during the liquid feeding period, decreasing by 23% (594 g/day) despite an approximately 20% higher intake of concentrate. For the whole experimental period, these differences were insignificant at 7 and 4%, respectively. Calves of group SL_{1/2} consumed a similar amount of concentrate and achieved similar weight gains as those from group SL, which received twice as much milk replacer.

In the other groups, calves consumed less concentrate but had higher daily liveweight gains. Feeding liquid feed (83 kg DM/calf) to appetite did not significantly affect daily concentrate intake and weight gains of calves in group TV compared with groups DL and TL, both during the liquid feeding period (838, 754 and 788 g/day, respectively) and during the whole experimental period (1080, 1026 and 1065 g/day, respectively). In all the groups after weaning, compensatory growth

resulted in high daily weight gains of calves above 1200 g/day ($P>0.05$). The highest compensatory growth was found in groups SL and SL_{1/2}.

KEY WORDS: calves, milk replacer, feeding frequency, feeding level, performance

INTRODUCTION

The majority of milk replacers currently used in European countries contain limited amounts of dried skim milk, which is the main source of protein during the period of liquid feeding of calves. Powdered milk is replaced with other milk products, e.g. whey, buttermilk and especially vegetable protein from legumes such as soyabean, peas and lupin (Kolar and Wagner, 1991; Turkur et al., 1995; Terosky et al., 1997; Lammers et al., 1998). However, legume proteins are less digestible than milk protein (Jenkins et al., 1980).

The aim of the present experiment was to find out whether the frequency and amount of a milk replacer that contains non-casein milk proteins and vegetable protein can affect the intake of concentrate and rearing performance of calves.

MATERIAL AND METHODS

The experiment was carried out with 54 Black-and-White calves, aged from 6-8 to 120 days, divided into 5 groups of 10 or 11 animals. In all the groups, calves were fed a milk replacer whose principal protein sources were dried skim milk, whey, buttermilk, and processed soya protein. Liquid feed was fed from 7 to 56 days of age once (S), twice (D) or three (T) times a day at limited feeding (L and L_{1/2}), or feeding to appetite (V). The concentration of solid milk replacer in liquid feed was 262 g per kilogram of liquid in group SL and 155.5 g per kilogram in groups DL, TL, SL_{1/2} and TV. The calves were fed milk replacer solutions to 56 days of age according to IZ-INRA (1997) recommendations. Rearing of one calf was assumed to consume about 54 kg of powder per calf in groups SL, DL and TL and about 27 kg of powder in group SL_{1/2}. Calves of group TV were fed milk replacer solution to appetite. All of the calves were given concentrate consisting of (%): ground barley, 50; wheat bran, 6; soyabean oilmeal, 17; ground wheat, 25; and mineral mixture 2. The mineral mixture consisted of the mineral additive Bovimix 75 % and Premix CJ Komplet 25%; in 1 kg of mixture, g/kg: Ca, 165; P, 90; Mg, 36.2; Na, 72.5; Fe, 2.24; Se, 0.011; Zn, 2.95; Cu, 1.31; Co, 0.08; Mn, 3.0; I, 0.09; Biotin 0.0015; vitamin E, 0.20 IU and vitamin A, 11250 IU.

The animals were fed individually and the intake of feed was monitored. They were kept in individual cages with automatic drinking bowls on an openwork plastic floor. Concentrate was fed to appetite and meadow hay from 0.10 kg/day du-

ring the milk replacer feeding period to 0.30 kg/day after weaning. Liquid feed was given from plastic buckets with nipples.

The nutrient content of the feeds was determined according to AOAC (1990), while the nutritive value of feeds and percentage composition of concentrate were evaluated according to the IZ-INRA system (1997) using Winwar ver. 1.6 (2000) and Winmix ver. 1.7 (2000) software packages. The rumen protein degradability coefficients (deg) and intestinal digestibility (dsi) for hay and concentrate components were adopted from INRA tables (1988). For milk replacers, was assumed that the value deg = 0 (due to the function of the reticular groove) and dsi = 0.96 (INRA 1988), which was equivalent to the digestibility of crude protein.

Statistical analysis of the results was performed using one-factor analysis of variance (SAS, 1988) and initial body weight was assumed as a concomitant variable.

RESULTS

Nutrient content and feed value are given in Table 1. The intake of milk replacer per rearing of one calf was 51 kg DM (groups SL, DL, TL), 26 kg DM (group SL_{1/2}) or 83 kg DM (TV). After weaning and for the whole rearing period, there were no significant differences among the groups in daily concentrate intake by the calves (Table 2). During the liquid feeding period, the intake of concentrate by calves from groups SL_{1/2} and SL was about 35 and 20% higher ($P < 0.05$) than by those from the other groups. During the same period, the nutrient intake of calves from group SL_{1/2} was the lowest and that of calves from group TV the highest ($P < 0.01$), while the differences between the other groups were not significant ($P > 0.05$). Similar correlations occurred for the whole experimental period, although the differences were not significant in all cases. After weaning, from 57 to 120 days of age, there were no significant differences among the groups in daily nutrient intake.

TABLE 1

Nutrient content in feeds, in 1 kg of DM

Feed	Dry matter %	Crude protein g	Ether extract g	Crude fibre g	Ash g	UFL	PDIN ¹ g	PDIE ¹ g
Concentrate mixture	87.40	187.9	23.9	47.0	33.1	1.14	130	130
Meadow hay	83.06	86.3	19.0	329.6	109.5	0.72	53	64
Milk replacer ²	95.68	222.4	176.4	-	66.0	1.55	211	

¹ PDI for milk replacer corresponds to digested crude protein

² 155 g powder in 1 kg of liquid feed (groups: SL_{1/2}, DL, TL, TV) or 262 g powder group SL

TABLE 2

Intake of concentrate mixture and nutrients

Item	Groups ¹					SE
	SL	DL	TL	SL _{1/2}	TV	
<i>Before weaning (from 7 to 56 days of age)</i>						
concentrate mixture, kg/day	0.41 ^b	0.32 ^a	0.34 ^{ab}	0.49 ^b	0.34 ^{ab}	0.055
dry matter, kg/day	1.40 ^A	1.32 ^A	1.35 ^A	0.99 ^C	1.98 ^B	0.051
crude protein, g/day	295.6 ^A	282.6 ^A	288.5 ^A	201.1 ^C	426.5 ^B	11.27
PDIN, g/day	262.7 ^A	255.0 ^A	258.7 ^A	169.3 ^C	389.7 ^B	10.54
PDIE, g/day	262.9 ^A	255.2 ^A	258.9 ^A	169.6 ^C	389.9 ^B	10.53
UFL/day	2.01 ^A	1.92 ^A	1.96 ^A	1.33 ^C	2.92 ^B	0.078
<i>After weaning (from 57 to 120 days of age)</i>						
concentrate mixture, kg/day	3.46	3.64	3.76	3.53	3.67	0.124
dry matter, kg	2.52	2.69	2.68	2.66	2.65	0.039
crude protein, g	461.2	494.3	493.0	487.5	486.7	10.12
PDIN, g	319.2	342.2	341.3	337.5	336.9	7.02
PDIE, g	320.5	343.5	342.6	338.8	338.2	7.02
UFL	2.83	3.03	3.02	2.99	2.98	0.062
<i>Whole experimental period</i>						
concentrate mixture, kg/day	2.13	2.17	2.26	2.19	2.21	0.275
dry matter, kg	2.40 ^{Cc}	2.45 ^{AaCc}	2.52 ^{AaBCc}	2.25 ^{Cc}	2.75 ^{Hb}	0.244
crude protein, g	456.6 ^{DJc}	466.8 ^{AaCDd}	480.5 ^{AaBDd}	420.9 ^{Cc}	532.7 ^{Hb}	45.85
PDIN, g	341.5 ^{AaC}	349.2 ^{Aa}	358.5 ^{Aa}	304.6 ^{Cc}	410.2 ^{Hb}	32.04
PDIE, g	342.6 ^{AaC}	350.2 ^{Aa}	59.5 ^{Aa}	305.6 ^{Cc}	411.2 ^{Hb}	32.07
UFL	2.89 ^{AaC}	2.94 ^{Aa}	3.30 ^{Aa}	2.62 ^{Cc}	3.41 ^{Hb}	0.280

abcd – P<0.05; ABCD – P<0.01

¹ S – once, D – twice, T – three times a day liquid feed offered; L – limited amount of milk replacer solutionL_{1/2} – restricted to the half portion of L, V – milk replacer offered *ad libitum*

Daily weight gains of calves of in groups SL_{1/2} and SL were about 27% lower during the liquid feeding period and 11% lower for the whole experimental period than in the other groups (Table 3). From weaning to the end of the experiment there were no significant differences among the groups in daily weight gains, which were high in all of the groups (over 1200 g/day).

Calves fed milk replacer solution before weaning once daily with both full milk replacer ration (group SL) of about 51 kg DM/calf and half of this amount (group SL_{1/2}) consumed more (P<0.05) concentrate per kilogram weight gain than calves in the other groups, among which no significant differences occurred (Table 4). Similar although less varied correlations for feed conversion also occurred for the

TABLE 3

Body weight and daily gains

Item	Group					SE
	SL	DL	TL	SL _{1/2}	TV	
Initial body weight ¹ , kg	45.6	43.6	43.9	46.3	50.1	-
Body weight at weaning, kg	75.6 ^b	83.6 ^A	85.3 ^A	74.7 ^b	87.8 ^A	1.73
Final body weight, kg	157.1	162.9	167.3	153.7	169.1	3.61
Body weight gain, g·day ⁻¹						
before weaning	594 ^b	754 ^A	788 ^A	576 ^B	838 ^A	34.6
after weaning	1273	1238	1281	1234	1270	45.5
for the whole experimental period	975 ^{CcFd}	1026 ^{AaCc}	1065 ^{AaCc}	946 ^{BbDd}	1080 ^{AaC}	31.7

¹ adjusted body weight was 45.9 kgabc – P<0.05; ^ABC – P<0.01

TABLE 4

Feed utilization, per 1 kg weight gain

Item	Group					SE
	SL	DL	TL	SL _{1/2}	TV	
<i>Before weaning (from 7 to 56 days of age)</i>						
concentrate mixture, kg	0.66 ^{CcFd}	0.41 ^{AaC}	0.44 ^{AaC}	0.83 ^{BbDd}	0.40 ^{AaC}	0.068
dry matter, kg	2.43 ^b	1.82 ^A	1.74 ^A	1.71 ^A	2.39 ^B	0.066
crude protein, g	516.0 ^b	389.3 ^A	371.0 ^A	348.7 ^A	515.5 ^B	14.55
PDI, g	461.6 ^b	351.7 ^A	333.2 ^A	294.9 ^A	471.9 ^B	13.78
UFL	3.52 ^B	2.65 ^A	2.52 ^A	2.31 ^A	3.53 ^B	0.101
<i>After weaning (from 57 to 120 days of age)</i>						
concentrate mixture, kg	2.74	2.95	2.94	2.90	2.90	0.096
dry matter, kg	3.18	3.33	3.43	3.23	3.35	0.038
crude protein, g	592.4	610.7	630.5	592.6	615.7	7.03
PDI, g	404.8	424.4	438.1	411.8	427.8	4.86
UFL	3.57	3.75	3.87	3.64	3.78	0.043
<i>Whole experimental period</i>						
concentrate mixture, kg	2.18 ^{AaCc}	2.12 ^{AaB}	2.13 ^{AaB}	2.32 ^{BbCc}	2.05 ^{Aa}	0.186
dry matter, kg	2.46	2.39	2.37	2.39	2.55	1.186
crude protein, g	468.6 ^{AaCc}	455.7 ^{AaB}	451.9 ^{AaB}	447.9 ^{Aa}	493.8 ^{BbCc}	35.32
PDI, g	351.8 ^{Cc}	341.9 ^{AaCc}	338.2 ^{AaCc}	325.6 ^{AaC}	381.2 ^{Bbc}	26.29
UFL	2.96 ^{Cc}	2.88 ^{AaCc}	2.85 ^{AaCc}	2.79 ^{AaCc}	3.15 ^{BbCc}	0.222

abc – P<0.05; ^ABC – P<0.01

whole experimental period. During the period from weaning to the end of the experiment, there were no significant differences in feed conversion among the groups ($P>0.05$).

DISCUSSION

The results obtained clearly demonstrate that once-daily liquid feeding of calves increases the intake of concentrate. However, daily nutrient intake was mainly affected by the amount of milk replacer per calf during the liquid feeding period. This is indicated by the lower intake of nutrients in group $SL_{1/2}$, in which a half less of the milk replacer (26 kg DM/calf) was used for rearing one calf than in group SL, while the feed intake of concentrate in both groups was similar. This is also confirmed by a similar intake of components in the groups of calves that received the same amounts of milk replacer per rearing of one calf (SL, DL, TL) and by an almost double intake of nutrients by calves from group TV who received milk replacer to appetite (87 kg DM/calf). The amount of concentrate had no effect on the intake of nutrients in these groups, because its intake was similar (an average of 0.32 or 0.34 kg/day and animal). The higher concentrate intake with once-daily liquid feeding of calves could result from an overlong interval (24 h) between the liquid feeding periods, which forced the calves to look for other types of food and thus to consume more concentrate than in the other groups. However, this did not have a beneficial effect on daily weight gains, probably because enzymatic activity of the calves' digestive tract had still been limited by rumen development status. A slightly higher (by about 7%) intake of concentrate in group $SL_{1/2}$ than in group SL suggests that this could also have resulted from the intake of less milk replacer in the daily ration of liquid feed, which was similar in both groups (about 3.8 kg/day) but the milk replacer concentration in this ration was different and the daily intake by the calves was 0.54 and 1.05 kg of the milk replacer, respectively. The marked decrease in daily weight gains observed in calves before weaning in groups SL and $SL_{1/2}$ lets us suggest that non-casein protein from milk and vegetable protein in the milk replacer had limited stability of liquid feed digestion in the digestive tract of calves with once-daily liquid feeding. Protein types like this are not affected by the action of rennin as they do not clot in the stomach and this increases the abomasal emptying rate and decreases protein digestibility in both the abomasum and small intestine (Petit et al., 1989; Van Kempen and Huisman, 1991). The lack of marked differences in daily weight gains between groups SL and $SL_{1/2}$ lets us suggest that the varying amounts of milk replacer fed in these groups did not have a significant effect on calf performance. The similar body weight gains of calves obtained in groups DL, TL and TV indicate that increasing the liquid feeding frequency and the feeding of liquid feed to appetite do not en-

sure improved performance. A certain tendency for slightly higher gains in calves liquid-fed to appetite (group TV) than in groups DL and TL suggests a greater nutrient flow through the digestive tract of the calves and higher nutrient digestion.

Better performance of the calves liquid fed twice and three times daily, especially of those fed to appetite, could also have been affected by the greater fat content of the daily ration than in the other groups, which averaged (g/day): 292 (group TV), 190 (DL, TL), 100 (SL_{1/2}) and 162 (SL). Doppenberg and Palmquist (1991) reported that calves fattened for white meat with low-fat liquid feed needed more time to achieve predicted final body weights. The lack of significant differences among the groups after weaning in daily weight gains and feed conversion per kilogram weight gain suggests that rumen activity led to compensatory growth regardless of the frequency and amount of milk replacer feeding. The considerably higher compensatory growth observed in groups SL and SL_{1/2} than in the other groups could have proceeded from the more rapid development of the rumen resulting from a slightly higher concentrate intake and better conversion of solid feeds (Foldager et al., 1997).

In conclusion, once-daily liquid feeding of calves during the liquid feeding period has a negative effect on performance despite increased concentrate intake and depends on the amount of milk replacer used for the rearing of one calf. Increasing the frequency of feeding with milk replacer (to 3 times a day) or the amount of milk replacer per rearing of one calf when feeding to appetite has no beneficial effect on performance compared with twice-daily liquid feeding of calves. Performance obtained for the whole experimental period depends only to a small extent on the results obtained during the liquid feeding period because the weaning of calves is followed by compensatory growth.

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STRESZCZENIE

Wpływ częstotliwości i poziomu żywienia cieląt preparatem mlekozastępczym na pobranie mieszanki treściwej i wyniki wychowu

Doświadczenie przeprowadzono na 54 cielętach buhajkach rasy cb w wieku od 6-8 do 120 dnia życia podzielonych na 5 grup po 10-11 zwierząt. Preparat mlekozastępczy zawierał mleko odtuszczone, serwatkę i maślanek w proszku oraz przetworzone białko soi. Paszę płynną skarmiano od 7 do 56 dnia życia z częstotliwością: jeden (S), dwa (D) lub trzy (T) razy w ciągu dnia stosując żywienie ograniczone (L bądź $L_{1/2}$) lub *ad libitum* (V). W czasie doświadczenia cielęta pobierały po: 54 kg stałego preparatu mlekozastępczego (grupy: SL, DL, TL) lub 27 kg proszku (grupa $SL_{1/2}$) lub 87 kg proszku (grupa 3TV). W grupach DL, TL, $SL_{1/2}$ i TV pasza płynna zawierała 155,5 g, a w grupie 3V - 262 g preparatu w 1 kg roztworu. Wszystkie cielęta otrzymywały mieszankę treściwą do woli i siano łąkowe w ilości 0,1-0,3 kg/dzień. Przy podobnym pobraniu preparatu mlekozastępczego (51 kg SM/cielęc) jednorazowe pojenie cieląt w porównaniu z 2 i 3 krotnym powoduje w okresie żywienia paszą płynną obniżenie dziennych przyrostów masy ciała o około 23% (594 g/dzień), mimo większego o około 20% dziennego pobrania mieszanki treściwej. Za cały okres doświadczenia różnice te były nieistotne i wynosiły 7 i 4%, odpowiednio. Cielęta z grupy $SL_{1/2}$ pobierały podobną ilość mieszanki treściwej i uzyskiwały podobne przyrosty masy ciała jak cielęta w grupie SL, otrzymujące 2 razy większą ilość preparatu mlekozastępczego. W innych grupach stwierdzono mniejsze pobranie mieszanki treściwej i większe przyrosty masy ciała ($P < 0,01$). Skarmianie do woli paszy płynnej (83 kg SM/ cielęc) nie miało istotnego wpływu na dzienne pobranie mieszanki treściwej i przyrosty masy ciała cieląt w grupie TV w porównaniu z grupami DL i TL, zarówno w okresie żywienia paszą płynną (odpowiednio: 838, 754 i 788 g/dzień), jak i w całym okresie doświadczenia (1080, 1026 i 1065 g/dzień). We wszystkich grupach po odłączeniu, w następstwie rekompensaty wzrostu, cielęta uzyskały wysokie dzienne przyrosty masy ciała, wynoszące ponad 1200 g ($P > 0,05$). Największa rekompensata wzrostu wystąpiła w grupie SL i $SL_{1/2}$.