Effect of curd suppression of a calf milk replacer fed at increasing levels on nutrient digestibility and body mass-gain

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Two groups of eight Friesland bull calves each were used in the trial. Calves received a commercial, coagulable milk replacer in which casein coagulation either was normal (CM treatment), or was prevented by the precipitation of Ca^{++} with an oxalic acid–sodium hydroxide buffer (NCM treatment). In both treatments, the daily milk replacer feeding level (percentage of birth mass) was increased from 9% (week 1), to 12% (week 2), 15% (week 3) and 18% (week 4). Calves were weighed at weekly intervals and occurrence of diarrhoea was monitored. At four weeks of age, five calves from each treatment were randomly selected for a digestibility trial of seven days. Body mass-gain and efficiency of feed conversion (kg dry matter/kg gain) were 10,4 kg and 1,7; and 10,7 kg and 1,6 for the CM and NCM treatments, respectively. Digestibility coefficients were 90,2 and 91,1% (dry matter), 91,9 and 93,6% (organic matter), and 81,0 and 85,6% (crude protein), for CM and NCM respectively. It was concluded that prevention of abomasal curd formation had no effect on body mass-gain, occurrence of diarrhoea, or digestibility of dry matter, organic matter and crude protein. Digestibility coefficients remained high, even at a daily feeding level of 18% of birth mass.

Twee groepe van agt Friesbulkalwers elk is in die proef gebruik. Kalwers het 'n kommersiële, koaguleerbare melksurrogaat ontvang waarin koagulering óf normaal was (CM-behandeling), óf voorkom is deur die presipitering van Ca^{++} met 'n oksaalsuur–natriumhidroksiedbuffer (NCM-behandeling). Daaglikse melksurrogaatvoedingspeil (persentasie van geboortemassa) het in albei behandelings toegeneem vanaf 9% (week 1), tot 12% (week 2), 15% (week 3) en 18% (week 4). Kalwers is weekliks geweeg en die voorkoms van diarree is gemonitor. Vyf kalwers uit elke groep is op vier-weke-ouderdom ewekansig geselekteer vir 'n verteringsproef van sewe dae. Massatoename en doeltreffendheid van voeromsetting (kg droëmateriaal/kg toename) was 10,4 kg en 1,7; en 10,7 kg en 1,6 vir die CM- en NCM-behandelings onderskeidelik. Verteerbaarheidskoëffisiënte was 90,2 en 91,1% (droëmateriaal), 91,9 en 93,6% (organiese materiaal) en 81,0 en 85,6% (ruproteïen) vir CM en NCM, onderskeidelik. Die gevolgtrekking is gemaak dat voorkoming van abomasale stolselvorming geen invloed op massatoename, voorkoms van diarree, of die verteerbaarheid van droëmateriaal, organiese materiaal en ruproteïen gehad het nie. Verteerbaarheidskoëffisiënte het hoog gebly, selfs teen 'n daaglikse voedingspeil van 18% van geboortemassa.

Keywords: Calves, milk replacers, casein curd formation, digestibility, body mass-gain.

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The unique ability of casein to coagulate in the abomasum of young ruminants, formed the basis of many documented studies on the effect of curd-forming ability of milk replacers on different physiological parameters in calves.

A number of researchers reported beneficial effects of firm abomasal curd development on nutrient digestibility and body mass-gain, mainly due to a slower release of nutrients from the abomasum (Hill *et al.*, 1970; Gorrill & Nicholson, 1972; Roy, 1974; Jenkins *et al.*, 1980; Jenkins & Emmons, 1982; Nikoajczuk & Zielinski, 1983). These authors also asserted that the absence of curd forming usually results in a higher frequency of diarrhoea. However, other studies indicated that the absence of curd forming did not impair digestibility or calf performance (Bouchard *et al.*, 1973; Thivend *et al.*, 1980; Petit *et al.*, 1989; Cruywagen *et al.*, 1990b). According to Paruelle *et al.* (1972) and Toullec *et al.* (1974), a lack of coagulation appeared to decrease digestibility more during the first 4—5 weeks than thereafter.

In many documented studies on the effect of coagulation on digestibility of nutrients, milk protein was either substituted by non-coagulable proteins, or predigested to render the protein incoagulable. In the present study, coagulation was prevented by the precipitation of Ca^{++}. It is therefore believed that coagulation *per se* was the only variable between treatments.

In a previous study on this subject, calves received milk replacer at a constant level for the duration of a 28-day trial (Cruywagen *et al.*, 1990b). It was postulated that, under conditions of nutritional stress such as increasing levels of milk replacer feeding above recommended levels, curd suppression may be deurimental to nutrient utilization. The present study was conducted to test this hypothesis.

Materials and Methods

Growth trial

Sixteen male Friesland calves, two days of age, were used in the trial. After weighing, calves were allotted to two treatments in a completely randomized design. Mean initial body mass of calves (kg $\pm SD$) was $35,5 \pm 4,2$ (CM treatment) and $34,6 \pm 4,4$ (NCM treatment) respectively. Animals were kept individually in $1,50 \times 0,60$ m elevated pens with expanded metal floors.

A commercial, coagulable milk replacer (23% crude protein and 13% fat), containing 40% skimmed milk powder, was used. Since it is a commercial product, no detailed information on the composition thereof can be supplied. Coagulation tests (*in vitro*) indicated firm clotting

ability of the milk replacer. These tests were based on the action of 1 p.p.m. rennet solution added to the reconstituted milk replacer maintained at 37 °C. Curd formation in the abomasum was prevented by precipitating Ca^{++} in the milk replacer with an oxalic acid (0,25M) – NaOH (0,35M) buffer solution. This buffer solution completely inhibited curd formation, and restored pH to 6,5 when added to the reconstituted milk replacer at a rate of 6,6 ml/10 g of milk replacer powder. Under these conditions about 70% of milk calcium was precipitated. Verification of this technique to prevent *in vitro* as well as *in vivo* curd formation was described by Cruywagen (1985) and Cruywagen *et al.* (1990a). Milk replacer was reconstituted with water (45 °C) to 13% dry matter (DM). The coagulating, untreated milk replacer was fed to one group (CM treatment), while the other group received the non-coagulating, oxalic acid-treated milk replacer (NCM treatment). In the latter treatment, a reaction time of 15 min was allowed before feeding to ensure sufficient Ca^{++} precipitation. Calves were bucket-fed twice daily at 08h00 and 16h00.

In both treatments, the level of milk replacer feeding (expressed as percentage of birth mass daily) was increased at weekly intervals as follows (feeding levels as percentage of average live weight during each week, as observed during the trial, are presented in parentheses for the CM and NCM treatments, respectively):

Week 1: 9% (9,1 and 9,2%)
Week 2: 12% (11,2 and 11,3%)
Week 3: 15% (13,2 and 13,0%)
Week 4: 18% (14,4 and 14,2%)

The trial lasted for 28 days, and calves were weighed at the end of each week.

Digestibility trial

After completion of the growth trial, five calves from each treatment were randomly selected for the digestibility trial. The last week of the growth trial was also the adaptation period for the digestibility trial, i.e. calves remained on 18% feeding level.

Faeces were collected for seven days. Collection was done quantitatively in preweighed plastic bags, attached to permanently fixed chute bags glued to the calves. Bags were changed daily and the wet faecal mass was determined accurately. The bags containing the quantitative wet excretion were stored at –25 °C up to the end of the collection period. After completion of the trial, faeces were thawed and the total excretion of each calf was pooled and then thoroughly mixed. Representative samples of *ca.* 200 g from each calf were dried in a forced draught oven for 24 h at 65 °C, and stored at 4 °C in airtight containers until required for chemical analyses.

For the determination of faecal DM content, samples from stored faeces were further dried at 105 °C to constant mass.

Faecal nitrogen content was determined colorimetrically with the aid of an automatic flow system, according to the method of Clare & Stevenson (1964). Crude protein was estimated as N × 6,25.

Results and Discussion

Body mass-gain, efficiency of feed conversion (EFC) and apparent digestibility coefficients of relevant nutrients are presented in Table 1.

Table 1 Body mass-gain, efficiency of feed conversion and apparent nutrient digestibility of calves receiving coagulable and non-coagulable milk replacers (x ± *SD*)

Item	Treatment[a]		Calculated F value
	CM	NCM	
Body mass-gain (kg over 28 days)	10,4 ± 2,3	10,7 ± 1,3	0,07 (NS)[b]
Efficiency of feed conversion (kg dry matter intake/kg gain)	1,7 ± 0,3	1,6 ± 0,3	0,85 (NS)
Dry matter digestibility (%)	90,2 ± 0,4	91,1 ± 2,0	0,87 (NS)
Organic matter digestibility (%)	91,9 ± 1,0	93,6 ± 1,7	3,67 (NS)
Crude protein digestibility (%)	81,0 ± 4,9	85,6 ± 4,7	2,25 (NS)

[a] CM = Coagulable milk replacer; NCM = non-coagulable milk replacer.
[b] Difference between treatments not significant.

Growth trial

Treatment had no effect on body mass-gain. In a previous study (Cruywagen *et al.*, 1990b) where calves received the same milk replacers at a constant level of 9% of birth mass, mean body mass-gains over 28 days were 4,3 and 4,9 kg for the CM and NCM treatments, respectively. Although the absence of curd formation did not affect calf performance in either study, increased feeding levels in the present study resulted in markedly improved gains. Jenkins & Emmons (1982) used a milk replacer where skimmed milk powder provided only 32% of total protein, and reported body mass-gains of 5,4 and 5,2 kg for calves, at four weeks of age, receiving coagulable and non-coagulable milk replacers respectively, where feeding level was 10% of body mass (BM) during the first week, and 12% up to four weeks of age. Differences between treatment means were not significant.

Efficiency of feed conversion was not affected by curd suppression. Feed conversion ratios in the previous study (Cruywagen *et al.*, 1990b) were 3,9 and 2,9 for the CM and NCM treatments, respectively. Jenkins & Emmons (1982) reported EFC ratios of 2,2 and 2,4 for calves receiving coagulable and non-coagulable milk replacers, respectively. Calves in the present study were highly efficient in converting milk replacer nutrients to body tissue. However, direct comparisons in EFC ratios are not always valid since, in many documented studies, feed intake was restricted in such a way that energy available for growth was marginal. Consequently, a large proportion of energy intake was used for maintenance.

Doubling the initial feeding level within three weeks of age did not appear to pose a nutritional stress on calves, and the lack of abomasal curd formation had no adverse effect on calf performance under these conditions. Treatments had no effect on the occurrence of diarrhoea. Mean diarrhoea days per calf were 1,2 (CM) and 1,3 (NCM).

Weekly body mass-changes are indicated in Figure 1. Although the mean initial body mass of calves in the NCM treatment was slightly (non-significantly) less than that of calves in the CM treatment, it is apparent that both groups followed the same growth pattern. The difference in mean body mass between the two treatments remained non-significant at every weekly interval, indicating that a lack of coagulation had no effect on growth rate of calves under conditions of the present study.

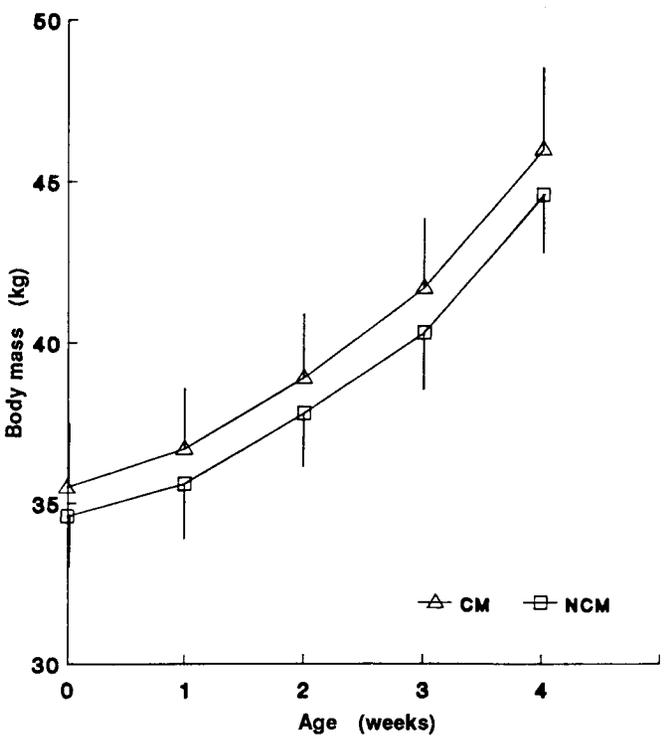

Figure 1 Weekly body mass-change of calves receiving either coagulable (CM) or non-coagulable (NCM) milk replacer diets. Vertical bars indicate standard errors.

Digestibility trial

No significant differences were found between treatments with regard to DM and OM digestibility (Table 1). It was reported in a previous study (Cruywagen *et al.*, 1990b) that the prevention of curd formation had no effect on DM or OM digestibility when milk replacer was fed at a constant rate of 9% of BM. Respective digestibility coefficients for the coagulable and non-coagulable milk replacers in the latter study were 91 and 86,6% (DM), and 91,8 and 88,4% (OM). Petit *et al.* (1989) reported DM digestibilities of 93,5 and 90,5% (difference not significant) for CM and NCM treatments, respectively, when milk replacers were fed at a constant rate of 10% of BM. However, they observed a significant decrease in ileal digestibility of dry matter by preventing curd formation. When feeding level was increased from 10% of BM during the first week, to 12% up to four weeks of age, Jenkins & Emmons (1982) also found no effect of curd inhibition on DM digestibility. They do add, however, that the clotting ability of the coagulable milk replacer was rather poor. Respective values were 95,7 and 95,5% for the coagulable and non-coagulable milk replacers. According to Toullec *et al.* (1974), curd prevention reduced digestibility coefficients only during the first three weeks of life.

The abomasal curd consists predominantly of protein (casein) and fat, and it has been shown that the CM treatment resulted in significantly ($P < 0,05$) extended abomasal CP retention (Cruywagen *et al.*, 1990a). Although Petit *et al.* (1989) reported that curd suppression had no effect on CP digestibility at a feeding level of 10% of BM, Cruywagen *et al.* (1990b) found a tendency towards lower CP digestibility with curd suppression, and at a 9% feeding level. It was anticipated that curd formation would enhance CP digestibility when feeding level is increased to 18% of BM. However, results of the present study suggested no treatment effect.

Age has a marked effect on digestibility (Lister & Emmons, 1976; Grongnet *et al.*, 1981; Akinyele & Harshbarger, 1983). In the foregoing study (Cruywagen *et al.*, 1990b), calves were seven days of age at the start of the digestibility trial, whereas calves were 14 days old in the study reported by Petit *et al.* (1989). In the present study, calves were already 24 days of age when the digestibility trial commenced. According to Toullec *et al.* (1969) and Toullec *et al.* (1974), suppression of coagulation had no effect on digestibility for calves after three weeks of age. This is in agreement with results of the present study. It would appear then, that age, as well as feeding level and milk replacer composition, are important factors to be kept in mind when results of studies on the effect of curd suppression are compared. It would also appear that feeding level and coagulation properties of milk replacers become less important with increasing age.

Conclusions

Prevention of curd formation in the abomasum of calves had no effect on body mass-gain, occurrence of diarrhoea, or digestibility of milk replacer components. The milk replacers in the present study contained mainly dairy products with a high biological value. Casein has the unique ability to coagulate in the abomasum of calves, and results suggested that curd formation *per se* had no effect on parameters mentioned. It is therefore not implied that substitution of high-quality milk proteins with other animal or vegetable proteins will manifest similar results as these obtained in the present study. In studies comparing various milk replacer formulations, it will therefore not be correct to explain differences in results merely in terms of the presence or absence of abomasal curd formation.

Results of the present study further suggest that digestibility coefficients of milk replacer components may remain high even at a daily feeding level of 18% of BM.

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