The role of curding and non-curding calf milk replacers in NZ calf-rearing systems

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Abstract

Calf milk replacers (CMRs) are typically formulated from a range of lower-value milk products and may have reduced curding ability when casein proteins are absent or denatured. Whilst there are industry claims that vealer calves in Europe can be reared on such CMRs, there is no NZ data to substantiate these claims. In Experiment One, 240 calves were reared on three milk replacers. Diet A was a curding CMR based on whole-milk powder and skim-milk powder. Diet B was a non-curding CMR based on whey and vegetable fat. Diet C was a non-curding CMR based on whey, soy and vegetable fat. A salmonella challenge occurred in the rearing facility during the first two weeks of rearing. Calves on Diet A suffered a much lower incidence of sickness than those on Diets B and C (15% vs 34% vs 61%) respectively. Mortality was also lower (1.25% vs 5% vs 5% respectively). In Experiment Two, 90 calves were fed on the same diets from four days to 13 weeks of age. There were no effects of diet on disease or mortality. Calves on Diet A, B and C had growth rates to 13 weeks of 0.63, 0.60 and 0.53 kg/day, respectively. In conclusion, rearers need to be aware that there a risk when feeding non-curding milk replacers to young calves, particularly when timely weight targets need to be achieved.

Keywords: calf milk replacers; curding; disease; growth rate

Introduction

When calves are reared by natural suckling they receive numerous small feeds of whole milk which curds in the abomasum because of the action of rennet on casein proteins. Historically, New Zealand calf-milk replacers (CMR) have been based on whole-milk and skim-milk powders unsuitable for export. However, in Europe and the US, it has become uneconomic to rear calves on skim-based CMRs (Davis & Drackley 1998) and non-curding whey CMRs have been developed and well tested under US and European conditions.

Whilst products containing whey and vegetable proteins are widely used in Europe, there are some fundamental differences when compared to New Zealand calf rearing systems. In Europe, calves are more robust as they are at least 7-10 days old before they are on-sold from the dairy farm. Calves in New Zealand are generally only four days old at point of sale and are less resistant to environmental challenges. They also tend to be fed on a once-a-day milk feeding regime. Two experiments were undertaken to examine the performance of young calves fed curding and non-curding CMRs under New Zealand conditions.

Materials and methods

Diet composition

Three calf milk replacers (CMR) were developed. A curding CMR was based on whole-milk powder and skim-milk powder (Skim). Two non-curding diets were based on whey and vegetable fat (Whey) and on whey, soy and vegetable fat (Soy). Diet formulations are given in Table 1. Diets were formulated to ensure that they were isocaloric (4500 kcal/kg) and similar in digestible protein (26 - 27%). Diets were formulated by an independent blender and independently tested (Table 2). This work was approved by the AgResearch Grasslands Animal Ethics Committee (AE 10202) and undertaken in spring 2004.

Experiment One

Calves were sourced from a wide range of suppliers in the Waikato and were transported by truck to the Poukawa Research Farm. Calves arrived in three batches, 116 calves on the 16th, 72 calves on the 19th, and 52 on the 22nd of August 2004. Calves were weighed and fed two litres of electrolytes on arrival (Dexolyte, Bomac Laboratories Ltd, New Zealand). The treatments consisted of the three CMR diets (skim, whey and soy) and two feeding regimes (once-a-day and twice-a-day) i.e. a 3 x 2 factorial with the treatment groups balanced for batch and arrival weight. The 240 calves selected were put into 30 pens of eight calves and all calves within each pen received the same treatment combination. The treatment allocation for the different pens was done on a random basis. Treatments started the day after arrival. The calves on the once-a-day regime were fed following the protocol outlined in Table 3. The pens allocated to twice-a-day feeding were fed a standard regime of two litres of CMR at a concentration of 125 g/litre i.e. 250 g/calf per feed at 8 am and 5 pm.

Chaffed meadow hay and calf pellets (Top calf 20% protein, Harvey Farms) were fed separately and made available *ad libitum*. All calves were checked individually for scouring twice-daily and all animal health issues recorded. All calves that scoured were treated with electrolytes for 24 hours. Any calf that would not drink was tube-fed electrolytes.

On the morning of the 25th August, five calves from the second batch of calves were found dead at the morning feed and the health of several others from the same batch had deteriorated. Post-mortem analysis gave a preliminary diagnosis of salmonella and this was confirmed by tissue and faecal samples. Tissue cultures showed a heavy growth

Table 1 Formulation of three calf-milk-replacer diets

Ingredients (%)	Skim	Whey	Soy
Whole milk powder	80.00	0.00	0.00
Skimmed milk powder	19.70	0.00	0.00
Whey protein concentrate 80%	0.00	22.80	14.00
Sweet spray dried whey powder, 12.50%	0.00	37.40	27.10
Protofett 50*	0.00	37.00	41.00
Soy protein concentrate**	0.00	0.00	15.00
Methionine	0.00	0.17	0.16
Vitamins and minerals	0.30	0.30	0.30
Monocalcium phosphate	0.00	1.95	1.80
Calcium carbonate	0.00	0.38	0.64

*Protefett 50 is a vegetable-fat-filled sweet whey powder (13.7% whey, 50% fat).

**Soy protein concentrate is a feed grade non-GMO soya protein extract designed for inclusion in calf milk replacers

Table 2 Laboratory analysis of the three calf-milk-replacer diets

	Skim	Whey	Soy
Crude protein (% of DM)	27.34	27.15	28.33
Fat (% of DM)	23.03	20.62	22.11
Ash (% of DM)	6.4	9.0	9.4
Lactose (% of DM)	43.23	43.23	40.16
E coli	Not found	Not found	Not found
Salmonella	Not found	Not found	Not found
S/C Visual Curd	Borderline-Good	No curd	No curd

Table 3 Feeding regime for once-a-day feeding treatment

Day	Amount fed
1-2	200g/1.50 l twice-a-day
3-4	350g/1.75 l once-a-day
5-6	400g/2.00 l once-a-day
7-8	450g/2.25 l once-a-day
9 on	500g/2.50 l once-a-day

of Salmonella typhimurium. From the evening of the 25th August, Tetravet (Bomac Laboratories Ltd, NZ) was added to the milk powder at a rate of 5 g/head for three days. Any calf that did not look normal in terms of its behaviour, stance, scouring or poor appetite was treated with 1 ml/10 kg Bivatop 200 (oxytetracycline, Boehringer Ingelheim Ltd). Calves generally responded to this treatment although some pens and individuals still looked in poor health, especially on the non-curding diets. Two days after the problem appeared (11, 8 and 5 days after arrival for the 1st, 2nd and 3rd batches of calves respectively) all calves were placed on a traditional skim-milk diet and the twice-a-day feeding regime as required by the animal ethics protocol.

Experiment Two

This experiment was undertaken by a commercial calf rearer under direct veterinary supervision. Ninety-three four-day-old Hereford x Friesian heifers calves were collected in two batches from a number of dairy farms in the Waikato and trucked to Hawkes Bay by commercial operators on the 14th and 17th September. Calves were weighed and fed electrolytes on arrival and 90 calves randomly allocated to pens of ten calves with three pens per treatment and fed the same CMR diets used in Experiment One. The day after arrival, calves were fed 225 g of each diet in 1.5 litres water at 10 am and 10 pm. This was continued for seven days. On day 8, 400 g in 2 litres water was fed once a day, this was increased to 500 g in two litres of water from day 9 until weaning. Pellets (Top calf 20% protein, Harvey Farms), straw and water were available *ad libitum* from day one. Calves were weighed on day 42 and calves that had gained more than 20 kg since arrival, were weaned and the remainder of the calves were weaned on day 49. Calves had access to grass and pellets *ad libitum* from week six to seven. From week seven to eight, the calves were fed 1.5 kg/head/day of pellets (Grow-up, 16% protein, Harvey Farms). From week eight to thirteen pellets were fed at 1 kg/head/day. The data was analysed using a Generalized Linear Model in Minitab for Windows with batch and initial liveweight fitted as covariates where needed.

Results

Experiment One

Calf health data is reported in Table 4. Treated calves were classed as those that were unwell (scouring, not feeding) and received an antibiotic injection, whereas sick-pen calves were those that couldn't walk and were carried to a sick pen. Calves fed the skim diet seemed more resilient to the salmonella challenge, as significantly more calves ($\chi^2 = 0.001$) remained healthy (85%) compared to calves on the whey (61%) and soy diets (34%). There was no evidence that once-a-day feeding led to higher levels

Table 4 Effect of dietary and feeding regime treatments on calf health (number of calves) during a salmonella challenge in Experiment One.

Treatment	Feeding Regime frequency	Healthy	Treated antibiotics	Sick pen	Died
Skim	Once-a-day	31	8	1	0
	Twice-a-day	36	2	1	1
	Total	67	10	2	1
	%	85.0	12.5	2.5	1.25
Whey	Once-a-day	24	14	2	0
	Twice-a-day	25	11	1	4
	Total	49	25	3	4
	%	61.25	31.25	3.75	5
Soy	Once-a-day	24	23	3	0
	Twice-a-day	13	21	4	4
	Total	37	44	7	4
	%	33.75	55.0	8.75	5
	Mean	60	32.9	5.0	3.8
	P*	0.001	0.001	0.16	0.35

*Treatment effects analysed using Chi square

Table 5 Effect of dietary treatment on calf live weight and liveweight gain in Experiment Two

Liveweight (kg)	Skim	Whey	Soy	SED	P
Initial	41.9	41.2	41.1	0.91	0.59
3 weeks*	50.3	50.1	49.6	0.79	0.61
5 weeks*	61.2	59.3	58.0	1.06	0.014
6 weeks*	68.2	67.3	64.3	1.25	0.006
10 weeks*	86.5	84.2	79.4	1.93	0.001
13 weeks*	101.8	99.2	92.4	2.37	0.001
No calves not weaned at 42 days	3	3	11		
Mean growth rate to weaning (g/d)	626	602	530	9.0	0.004

* Liveweights fitted with initial LW as a covariate

of infection (Table 4). The second batch of calves were hit hardest and this reinforced the view that the infection came in with these calves. Nevertheless, the treatments were randomly allocated and milk pens were next door to, or between, badly affected whey and soy pens. No pathogens were detected in a subsequent analysis undertaken on the milk powders.

Experiment Two

In this experiment, calves fed on the skim (curding) diet were significantly heavier from 5 weeks of age than the calves fed on the soy diet, with the weights of the whey calves being intermediate (Table 5). By 13 weeks of age, calves on the skim CMR were, on average, 9.4 kg heavier than the calves fed the soy CMR. There was no evidence of any diet effects on calf health or mortality.

Discussion

In calves up to three weeks of age, the digestive system is poorly developed and the calf can only digest a limited range of carbohydrates, fats and proteins (Davis & Drackley 1998). Longenbach & Heinrichs (1999) suggested that curding in the abomasum is actually necessary to enable the calf to fully utilise complex proteins. The curd that forms in the abomasum with a casein-based product (i.e. skim milk) is slowly digested and released into the small intestine while non-curding products (e.g. whey) pass rapidly into the small intestine. The importance of curd formation has been heavily debated. Roy (1970) suggested that the lack of curd formation in the abomasum would result in a more rapid flow of undigested protein into the duodenum, overwhelming the capacity of the small intestine and cause scouring. Calves under three weeks of age have less developed digestive systems and may be less able to cope with this increased flow of protein into the small intestine when a whey-based diet is fed (Huber 1969, Roy & Stobo 1975). Roy (1980b) speculated that the undigested protein and the increased pH of the abomasal outflow might allow overgrowth of pathogenic bacteria in the duodenum. The effects would be dependent on the immune status of the calf and the amount of pathogen challenge the calf is exposed to (Roy 1980a). Donnelly et al. (1976) also found increased scouring and a poorer ability to cope with a salmonella challenge when damaged skim milk powders (i.e. non-curding) were fed to calves under environmental stress. It would appear that this is what happened in Experiment One and that treatment effects became obvious because of the large numbers of calves in the trial. Calves fed the skim diet appeared much better equipped to meet the bacterial challenge and had lower levels of sickness and death.

Other studies (e.g. Terosky et al. 1997; Lammers et al. 1998) have added antibiotics (oxytetracycline and neomycin) to improve calf health when whey proteins were used in very young calves. Tomkins et al (1994) showed that antibiotics had the largest effect over the first two weeks of life and that the benefits of including low levels of antibiotics in the milk (oxytetracycline, chlortetracycline and neomycin) were greater when calves were raised intensively in large numbers, or when raising calves from a number of different environments, or when calves were subject to transport stress. In recent years, the use of antibiotics in CMRs has been banned and other compounds (e.g. acidifiers) have been added to non-curding milk replacers to improve feed intake, enhanced digestion and reduce scouring (Fallon & Harte 1980). The suggested mechanism was that acidification of the milk replacer lowered the pH of upper digestive tract and suppressed bacterial growth. No acids were added to the CMR formulations used in the current experiment but whey products sold in New Zealand do appear to have added acids.

Experiment Two showed that in the absence of a significant pathogen challenge, young calves can be reared on non-curding CMRs, albeit at a cost in terms of liveweight gain. This is significant in a New Zealand context when rearers need to on-sell 100 kg calves into a seasonal grass market and where rapid price drops are common.

Compared to European vealer systems where non-curding CMRs are in common use, many of the calves reared in New Zealand are extremely vulnerable due to their age when shifted from the dairy farm, stress of transport, adverse weather conditions, lack of colostrum (Vermunt et al. 1995), the large size of some rearing operations (up to 5000 calves reared) and the mixing of calves from a number of sources. The inconsistency of pathogen challenge coupled with different levels of on-farm management and animal health may explain the widely varying anecdotal reports of the success or failure of non-curding calf milk replacers. It is important to note that the term “non-curding” is also used to cover skim-based CMRs which may also fail to curd because of excessive heat treatment. Rearers need to be aware of the risks of feeding non-curding CMRs to very young calves. It is interesting to note that in a survey of 100 New Zealand rearers, 18 had fed non-curding whey powders to very young calves but 13 of these would not do so again (Thomson et al. 2018).

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