Evaluation of growth performance and NRC Nutrient Requirements for liquid fed Holstein calves under South African conditions

S.M. Grobler[1#] and L.J. Erasmus[2]
[1] Livestock Business Division, Agricultural Research Council, Pretoria 0002, South Africa
[2] Department of Animal & Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa

Abstract

Twenty four Holstein heifer calves were used in a completely randomized block design, and fed either 2 L of full milk (FMS) or experimental milk replacer (EMSS) twice daily with *ad lib* access to a commercial calf starter. The purpose of the study was to obtain growth data on the experimental milk replacer and compare that to growth data from milk fed calves. Body weight and skeletal development were measured weekly and faecal consistency was subjectively scored daily. Starter intake was 0.30 kg/d and 0.34 kg/d respectively at 35 days of age and 1.11 kg/d and 1.10 kg/d for FMS and EMSS calves respectively at 56 days. Body weight decreased from birth up to week two after birth. Body weight increased from week two onwards as age increased. The ADG for the 56-day experiment were 370 g/day for both FMS and EMSS. Based on literature studies where a milk replacer similar to EMSS was compared to full milk, one would have expected calves receiving full milk to have a higher ADG than the calves receiving milk replacer. However calves were housed in a relatively cold environment with very little shelter and *Cryptosporiduim* spp. was isolated in some of the calves. This probably impacted on the results. The growth prediction with the NRC showed that the NRC growth predictions are in agreement from week 6 onwards with the current study‘s growth results, and can be used with confidence by South African producers

Keywords: Holstein calves, full milk, milk replacer, growth, NRC
Corresponding author. E-mail: mgrobler@arc.agric.za

Introduction

Since 1997 the number of milk producers in South Africa decreased on average by 41% and currently there are only 3899 milk producers left (Coetzee & Maree, 2007). Raising dairy heifers from birth to calving has been found to comprise the second largest expense on the dairy farm since no revenue is derived until the onset of lactation (Heinrichs, 1993). The quality and cost of ingredients utilized in milk replacers, therefore, is becoming increasingly important (NRC, 2001). Heifers should be raised in an inexpensive way to be healthy and fast growing replacements that will reach age at first calving at the earliest time possible without sacrificing lifetime milk yield (Engstrom, 2005), for them to express their genetic potential for milk production at calving (Quigley, 2005).

When cost effective milk replacers such as the experimental milk replacer used in this study, which contains plant fats, could guarantee similar growth results as full milk which only contains milk fats and is readily available on the local market, then milk producers would have confidence in using these replacers instead of full milk. This would ensure that more milk is available for human consumption, produced at acceptable production costs (H. Olivier, Clover SA, personal communication, holivier@clover.co.za).

An important development in the feeding and management of dairy cattle has been the release of the NRC Dairy 2001 (NRC, 2001). Many producers are reluctant to use the calf and heifer growth recommendations since these have not been validated under South African conditions. There is an urgent need for such validation as it would be beneficial to both the feed industry as well as the milk producer.

The purpose of this study was therefore to obtain growth data when feeding an experimental acidified milk replacer plus calf starter in comparison with full milk feeding plus calf starter and to validate the NRC Dairy (2001) calf model under South African conditions.

Materials and Methods

Twenty four Holstein heifer calves were used in a completely randomized block design to compare the feeding of an experimental milk replacer to the feeding of full milk. The calves were blocked according to body weight at birth and randomly allocated to one of the two treatments receiving either experimental milk replacer with starter or full milk with starter within each block for an experimental period of 56 days. The birth weight of the calves varied between 34.5 and 43.0 kg. The differences in weight of the two calves within each block were less than 1 kg at birth.

Calves were fed 2 L of colostrum within 6 hours after birth and another 2 L within 12 h after birth. Colostrum feeding continued until day three when calves were switched over to the experimental treatments. The milk replacer contained 20% crude protein and 12% fat. The chemical composition is shown in Table 1. Because of a confidentiality agreement the ingredient composition cannot be published.

Table 1 Composition of the experimental milk replacer

Ingredients	%DM
Moisture	≤ 5.0%
Fat content	≥ 12.0%
Protein	≥ 20.0%
Lysine	≥ 1.4%
Methionine and Cysteine	≥ 0.9%
Minerals (Ash)	≤ 8.0%
Fibre	≤ 0.5%
Calcium	1.3 – 1.5%
Phosphorus	0.8 – 0.9%
Magnesium	0.06%
Copper	10 mg/kg
Manganese	50 mg/kg
Cobalt	18 mg/kg
Iron	60 mg/kg
Vitamin A	40 000 IU/kg
Vitamin C	120 mg/kg
Vitamin D3	10 000 IU/kg
Vitamin E	50 mg/kg
Virginiamycin	60 mg/kg
Anti-oxidant	35 mg/kg
pH	3.9 – 5.0
Sediment (Disc)	≤ 22.5 mg / 25g
Solubility index	≤ 5.0 mL

(Clover SA, Reg. Nr. V7174 Act 36/1947).

Calves were bucket fed 2 L of milk or milk replacer twice daily at 08:00 and 15:00. Great care was taken to feed the milk and milk replacer at the same temperature (30 ºC) every day. Water was available *ad lib* except for 30 minutes before and after liquid feedings. Additionally the calves had *ad lib* access to a commercial calf starter (Meadow Calf Starter - Tiger milling & feeds LTD, Reg. No. V 12012). The chemical composition of the calf starter is shown in Table 2.

Calves were moved to individual pens at day one of age. The pens were 6 m x 2.5 m. One third of each pen was roofed and the floor consisted of concrete, the remainder being soil surface. Every pen had a platted rubber matt on the concrete floor to function as bedding for the young calves.

After birth the calves' navels were disinfected with an Iodine solution to prevent navel ill and other infections and extra teats were removed. No dehorning was done during the trial period to minimize stress. Because it was the dairy's practice not to vaccinate calves, no vaccinations were given to trial animals.

The only illness found during the trial was diarrhoea. All sick animals were treated according to the diagnosis by a veterinarian. When the faecal score was higher than 2 (see description later) and the rectal temperature exceeded 39.5 °C antibiotics were administered for three days. When calves were visibly dehydrated electrolytes were given to the calves twice daily at 10:00 and 13:00. Milk feeding continued as usual. Calves were weighed at birth and thereafter every week until 56 days when the trial ended.

Table 2 Nutrient composition of the commercial calf-starter[1]

Ingredients:	g/kg
Protein (Min)	180
Fat (Min)	25
Fibre (Max)	150
Moisture (Min)	120
Phosphorus (Min)	3.5
Calcium (Max)	8.0
Medication:	
Albac[2]	15 ppm/100g/t
Romensin[3]	15 ppm/75g/t

[1]Tiger milling & feeds LTD, Reg. No. V 12012, [2]Zinc Bacitracin (Insta Vet), [3]Monensin, monosodium salt (Elanco Animal Health).

When heifers calve for the first time they should not only have achieved a target body weight but also a target body size. It is therefore essential to monitor skeletal development alongside body weight. The following body stature measurements were taken weekly when weighing the calves.

(i) Shoulder height – Measured at the highest point of the calf's withers.
(ii) Body length – Measured straight from the shoulder joint to the hip joint.
(iii) Chest diameter – Measured snug but not too tight around the heart girth just behind the front legs and shoulder blade.
(iv) Body depth – Measured from just behind the front legs to the calf's withers.
(v) Shoulder width – Measured at the widest part of the two shoulder joints.

All measurements were taken while the calves were standing comfortably on a clean, hard, level surface with their heads upright and looking forward.

The faecal consistency was subjectively scored every morning before feeding in order to assist in the evaluation of the health status of the calf as well as the treatment of diarrhoea. A scoring system from 1 to 4 as described by Larson *et al.* (1977) was used with:

1 firm, well-formed faeces
2 soft pudding like faeces
3 runny pancake batter (beginning of diarrhoea)
4 watery-liquid like substance faeces that can be described as severe diarrhoea.

An ANOVA was performed to test for differences in calf performance. The data was acceptably normal, with homogeneous treatment variances. Tukeys honest least significant difference (LSD) was used to separate means at the 5% level.

Results and Discussion

All calves readily consumed the volume of full milk (FM) or experimental milk replacer offered during each feeding; the experimental milk replacer therefore did not cause any palatability problems.

The weekly mean body weight and weekly mean starter intake for the two experimental groups are shown in Table 3

Starter consumption was negligible for the first three weeks of the trial, averaging less than 0.2 kg/d from 15 - 21 days of age. This data is comparable with a study conducted by Akayezu *et al.* (1994) where a starter intake of less than 0.20 kg/d at 18 days of age was recorded. In the current study starter intake was 0.30 kg/d and 0.34 kg/d respectively at 35 days of age and 1.11 kg/d for FMS calves and 1.10 kg/d for EMSS calves at 56 days at the end of the trial ($P > 0.05$). No differences were observed in weekly body weight change between the treatments ($P > 0.05$). The average body weight during week 8 was 60.3 and 60.2 kg for the FMS and EMSS group respectively.

Table 3 Weekly mean body weight and starter intake for calves receiving full milk plus starter or experimental milk replacer plus starter

	Body weight (kg)			Starter intake (kg)		
Day	FMS[1] (±s.e.m.)[3]	EMSS[2] (±s.e.m.)[3]	P =	FMS[1] (±s.e.m.)[3]	EMSS[2] (±s.e.m.)[3]	P =
0	39.4(±0.11)	39.6(±0.11)	0.31	-	-	
7	37.0(±0.43)	38.2(±0.43)	0.07	0.16(±0.02)	0.2(±0.02)	0.91
14	37.3(±0.59)	38.0(±0.59)	0.44	0.26(±0.05)	0.3(±0.05)	0.31
21	39.5(±0.78)	39.3(±0.78)	0.80	1.20(±0.23)	1.0(±0.23)	0.64
28	41.7(±0.77)	41.8(±0.77)	0.91	2.07(±0.30)	2.4(±0.30)	0.46
35	45.8(±0.89)	45.5(±0.89)	0.82	3.12(±0.35)	3.8(±0.35)	0.20
42	50.0(±1.00)	50.0(±1.00)	1.00	5.41(±0.49)	6.0(±0.49)	0.42
49	55.4(±1.21)	54.4(±1.21)	0.59	6.85(±0.57)	7.2(±0.57)	0.69
56	60.3(±1.19)	60.2(±1.19)	0.94	7.74(±0.58)	7.7(±0.58)	0.99

[1]FMS: full milk plus starter, [2]EMSS: experimental milk replacer with starter, [3]SEM: standard error of the mean.

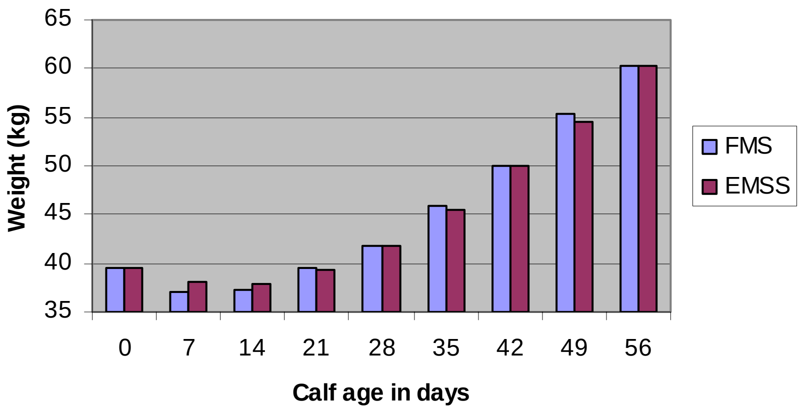

Figure 1 Weekly body weight change (kg) of calves fed either full milk and starter (FMS) or experimental milk replacer and starter (EMSS).

As shown in Figure 1, body weight increased from week two onwards as age increased. The decrease in body weight from birth up to week two can be expected because of stress, and sensitivity towards cold temperatures and diarrhoea that is more common within the first two weeks of life. This is consistent with other studies such as a study conducted by Kühne *et al.* (2000) where calves' body weight also decreased during the first week of life.

When the average daily consumption of starter is calculated over the first six weeks it amounts to 291 g/d (FMS) and 326 g/d (EMSS) respectively. This is approximately 100 g/d lower than the intake of 408 g/day for calves reported by Lammers *et al.* (1998) where mean *ad lib.* starter intake (21% CP) was monitored from birth up to six weeks of age with an overall ADG of 469 g/d. These researchers also found that ADG was highly correlated with total starter intake ($r^2 = 0.72$).

The mean difference between birth and weaning weight and mean ADG is shown in Table 4. The growth and ADG did not differ between the two treatments (P >0.05)

Table 4 Body weight gain and average daily gain of calves fed either full milk plus starter or experimental milk replacer plus starter

Item	FMS[1] (±s.e.m.)[3]	EMSS[2] (±s.e.m.)[3]	P =	CV%
Change in body weight (kg)	20.92 (± 1.65)	20.63 ± (1.66)	0.86	19.4
Average daily gain (kg)	0.37 (± 0.03)	0.37 ± (0.03)	0.84	19.6

[1]FMS: full milk plus starter, [2]EMSS: experimental milk replacer plus starter, [3]SEM: standard error of the mean, coefficient of variance.

The ADG for this 56-day growth study were 370 g/day for both FMS and EMSS (P >0.05). This gain was somewhat lower than the ADG of 408 g/d found by Van de Haar (2004) for calves fed a commercial milk replacer (21.3% CP and 21.3% fat) at 1.2% of body weight and calf starter (20.5% CP) at restricted intake.

Morril *et al.* (1995) reported an ADG of 302 g/day and 319 g/day for calves fed milk replacer containing bovine and porcine plasma respectively, for 43 days. Calves in the Morrill *et al.* (1995) study were fed 454 g of milk replacer per day until weaning at approximately 35 days and weighed approximately 54 kg at six weeks of the study (seven weeks of age). This is slightly lower than the mean of 55.4 kg and 54.4 kg for FMS and EMSS calves in the current study.

ADG gain of calves receiving FMS and EMSS were similar to other studies (Heinrichs *et al.*, 2003) where milk replacer contained milk and plant proteins. Intake increased as age and body weight increased. By week 8, calves of both FMS and EMSS consumed 1.1 kg starter per day. Quigley & Bernard (1996) also reported a starter intake of 1.1 kg/day by week 8. The average daily gain in the latter study averaged 473 g/day, however milk replacer intake increased as age and body weight increased, therefore the total nutrient intake was higher than in this study and therefore not fully comparable. By week 8, the calves consumed 700 g of DM of the milk replacer per day while the calves in the current study received only 500 g of DM of the milk replacer or 4 L full milk. Differences between intake of calf starter in this study and those from other reports (Quigley *et al*., 1992; Quigley *et al.*, 1994) were probably due to differences in amount of milk replacer fed and type of calf starter offered. It is therefore imperative that when ADG from different studies is compared it should be done on the basis of nutrient intake and nutrient content from either starter or liquid feed to ensure a fair comparison.

Mean body weight at 56 days of age were slightly lower than the guidelines suggested by Linn *et al.* (1989) and the growth standards of herd replacements published by Heinrichs & Hargrove (1987) and by Hoffman *et al.* (1992) for dairy calves of similar ages. Reasons for this result include possible differences in feeding management, experimental procedures, and genetic bases of the populations studied. Nevertheless, if 350 kg is considered to be the optimal bodyweight of heifers at breeding (Moss, 1998), and if this body weight is to be attained by 14 months of age, then two month old calves with mean body weight similar to calves receiving the experimental milk replacer plus starter and full milk plus starter must grow at rates of 0.79 kg/d to attain the target weight of 340 kg at 14 months of age. These rates of gain are achievable under good management practices. However, various feeding and management factors, such as group size, feedbunk management, dry matter intake, roughage quality, crude protein and energy content of diets, source and degradability of protein, and feeding management (restricted *vs. ad libitum*), may affect calf response and growth rate (Akayezu, 1994).

The lack of treatment effects on ADG (Table 4) indicates that the experimental milk replacer sustained growth in a similar way as full milk. Based on literature studies where a similar milk replacer as used in our study was compared to full milk, one would have expected calves receiving full milk to have a higher ADG than the calves receiving milk replacer. However these calves were housed in a relatively cold environment with very little shelter and *Cryptosporiduim* spp. were isolated in some of the calves. This could have impacted on the results.

The weekly means of changes in body stature (height, length, width, depth and chest diameter) are shown in Table 5.

Table 5 Effect of full milk plus starter or experimental Milk Replacer plus starter on the change in body stature[1] measurements between birth and 56 days of age ± Standard error of the mean (± s.e.m.)

	Height[1] (cm)	Length[1] (cm)	Width[1] (cm)	Depth[1] (cm)	Heart girth[1] (cm)	Weight (kg)	ADG (kg)
FMS[2] (± s.e.m.)□	7.0 (± 0.68)	10.0 (± 0.78)	2.9 (± 0.33)	6.1 (± 0.42)	13.2 (± 0.82)	20.9(±1.65)	0.37 (± 0.03)
EMSS[3] (± s.e.m.)□	8.5 (± 0.67)	9.5 (± 0.64)	2.3 (± 0.33)	5.3 (± 0.55)	12.9 (± 0.72)	20.6(±1.65)	0.37 (± 0.03)
P value	P = 0.17	P = 0.47	P = 0.29	P =0.23	P = 0.85	P = 0.86	P = 0.85
CV%□	31.3	16.8	49.4	25.4	23.5	19.4	19.6

[1]Body stature: Shoulder height – Measured at the highest point of the calf's withers.
Body length – Measured straight from the shoulder joint to the hip joint.
Shoulder width – Measured at the widest part of the two shoulder joints.
Body depth – Measured from just behind the front legs to the calf's withers.
Heart girth – Measured snug but not too tight around the heart girth just behind the front legs and shoulder blade.
[2]FMS: Full milk plus starter, [3]EMSS: experimental experimental milk replacer starter, □s.e.m.: standard error of the mean, □CV%: coefficient of variance.

Birth heights for FMS and EMSS were 75.8 cm and 75.0 cm respectively (P >0.05). These heights compare well with birth heights reported in a study by Franklin, *et al.* (1998). Calves in the latter study, which included bulls and heifers, also received a calf starter (14.8% protein and 3.3% ether extract) with 4.6 kg of pooled waste milk supplemented with vitamin A. Franklin *et al.* (1998) found that gender had an effect on body measurements at birth but that body weight, wither height, and body length increases were not affected (P <0.05) by gender or by supplementation of vitamin A to the full milk fed to the calves. At 4 weeks of age Franklin *et al.,* 1998 found an average height of 79.7 ± 0.4 and 80.2 ± 0.5 whereas calves' heights in the current study were 77.8 ± 0.42 (FMS) and 78.2 ± 0.42 (EMSS) respectively (P <0.05). Calves in our study were taller when compared to Franklin *et al.* (1998) calves. This is most probably due to differences in methodology utilized when measuring body stature over the period from birth to 42 days.

Calves in the current study's average increase in height over the period from birth to 42 days of age were 0.11 cm/d for FMS and 0.14 cm/day for EMSS. This compares well to results from Lammers *et al. (*1998) where the average growth in height at 42 days was between 0.13 and 0.16 cm/day. The heights found at 42 days by Franklin *et al.,* 1998 were 82.4 and 82.8 cm while heights at 42 days in the current study were 80.3 ± 0.4 cm (FMS) and 80.8 ± 0.4 cm (EMSS) (P >0.05).

Initial chest diameter differed between 80.1 cm and 82.6 cm and growth in chest diameter over the six week period differed between 0.22 and 0.24 cm/day whereas initial chest diameter for (FMS) was 77.67 cm and 78.92 cm for (EMSS) and growth for FMS was 0.19 and 0.17 for EMSS.

The error associated with the relatively crude measurement techniques used along with the small degree of skeletal growth during this period, makes it difficult to detect possible differences. With calves on accelerated growth programs where average daily gains of up to 0.9 kg/day can be achieved, differences would probably be more profound (Lammers *et al*., 1998).

The effects of feeding either FMS or EMSS on the average number of diarrhoea days from birth to 56 days are shown in Table 6. A faecal score 3 would indicate the beginning of diarrhoea and a faecal score 4 would indicate severe diarrhoea. Only the total amount of days where calves scored 3 or 4 on faecal consistency over the 56 day trial period are included in Table 6 to indicate the occurrence of diarrhoea during the trial period.

The group average of total number of days during the 56 day trial where calves showed symptoms of diarrhoea was five days for FMS and seven days for EMSS calves. The total number of days where severe diarrhoea was observed was three days for FMS calves and six days for EMSS calves during the 56 day trial period. Faecal scores generally peaked at week 2 and declined thereafter, although scores remained somewhat higher in week 4 and 5 for EMSS calves compared to FMS calves. Franklin *et al.* (1998) reported mean weekly faecal scores highest during week 2 and week 3 which is in agreement with the current study.

Table 6 Effect of feeding full milk plus starter or experimental milk replacer plus starter on the amount of diarrhoea days from birth to 56 days by means of faecal scores

	Group average of total amount of days over the 56 day trial period where calves showed beginning of diarrhoea or severe diarrhoea	
	Faecal score 3[1]	Faecal score 4[1]
FMS[2] (±s.e.m.)□	5.1 (± 1.18)	3.3 (± 0.85)
EMSS[3](±s.e.m.)□	6.8 (± 1.18)	6.1 (± 1.4)
P value	0.02	0.22
CV%□	26.4	110.4

[1]Group average of total amount of days over the 56 day trial period where calves scored a faecal score 3 or 4 respectively. Faecal score 3: runny, pancake batter (beginning of diarrhoea) and Faecal score 4: liquid splatters (severe diarrhoea).
[2]FMS: full milk plus starter, [3]EMSS: experimental milk replacer plus starter, □SEM: standard error of the mean, □CV%: coefficient of variance.

With the release of the 2001 National Research Council Nutrient Requirements for Dairy Cattle (NRC, 2001), a more useful approach to feeding calves has been developed. The Dairy NRC employs a more mechanistic approach to calf growth and development than previously utilized, and with adoption of the system the industry will be encouraged to re-evaluate the one-size fits all approach to calf feeding that currently exists (Van Amburgh, 2003). It provides reasonable estimates of the animal's nutrient requirements and is consistent with the remainder of the publication regarding tabular values and estimates of nutrient requirements. The estimates of energy requirements for young calves are more consistent with existing literature and can provide nutritionists and other dairy professionals with legitimate means to model dairy animal growth and select management strategies to optimize profitability. The latest edition of the NRC uses metabolisable energy for calves. This system is the most commonly used method of calculating an animal's energy requirement and the energy content of feeds. However many South African producers are reluctant to use the calf and heifer growth recommendations since these have not been validated under South African conditions.

The estimated growth as predicted by the NRC at different temperatures with the same nutrient intake as calves in the current study receiving full milk and starter are shown in Table 7. A 39.4 kg calf fed full milk at 4 L/day would be predicted to gain between 0.23 and 0.40 kg per day. However calves lost weight during the first week of the trial. This weight loss can be due to various stress factors. During the second week of the trial calves were predicted to grow at a rate of 0.28 – 0.41 kg per day but the actual growth was 0.03 kg per day.

From week six onwards the NRC 2001 guidelines were in agreement with the growth of calves in the current study. The starter intake was negligible during the first two weeks of life and from week 3 onwards intake started to increase. At week 3 of age the NRC estimated an energy allowable ADG of 0.38 kg/day at 5 °C and the calves in the current study grew at a rate of 0.32 kg/day. That constitute to a difference of 60 g growth per day and therefore the real growth and NRC prediction is very much compatable. From week 6 onwards the NRC guidelines were comparable with the current study with less than 100g difference between the predicted and actual growth rates. The results from this study suggest that the NRC program predicts growth more accurately during the latter stage (4 - 8 weeks) of the calf growth phase compared to the initial growth phase (1 - 3 weeks). This is most probably related to the effect of housing which is very much different between the US and South Africa; in the US calves are housed indoors during cold temperatures.

The estimated growth as predicted by the NRC at different temperatures with the same intake as calves in the current study receiving experimental milk replacer and starter are shown in Table 8.

At seven days of age the calves lost 0.20 kg per day and the NRC predicted weight loss at 5 °C. In the second week of life the calves in the current study lost 0.03 kg per day and the program estimated an energy allowable gain of 0.16 kg per day which comes to a difference of 0.19 kg growth per day between the real growth and the NRC estimated growth.

Table 7 Average daily gain(kg) of calves fed full milk and starter compared with NRC (2001) estimation of ADG with the same nutrient intake at different temperatures

	NRC (2001) ADG growth prediction at different temperatures								Actual starter intake and ADG	
Day	NRC est. 5 °C		NRC est. 10 °C		NRC est. 15 °C		NRC est. 20 °C		Daily Starter Intake (kg)	Actual ADG
	Energy Allowable ADG	ADP Allowable Gain	Energy Allowable ADG	ADP Allowable Gain	Energy Allowable ADG	ADP Allowable Gain	Energy Allowable ADG	ADP Allowable Gain		
7	0.23	0.40	0.30	0.40	0.37	0.40	0.44	0.40	0.02	-0.35
14	0.28	0.41	0.42	0.41	0.42	0.41	0.48	0.41	0.03	0.05
21	0.38	0.47	0.44	0.47	0.51	0.47	0.57	0.47	0.17	0.32
28	0.44	0.53	0.50	0.53	0.57	0.53	0.63	0.53	0.30	0.31
35	0.51	0.59	0.57	0.59	0.64	0.59	0.70	0.59	0.45	0.59
42	0.66	0.74	0.72	0.74	0.78	0.74	0.84	0.74	0.77	0.60
49	0.72	0.83	0.78	0.83	0.85	0.83	0.91	0.83	0.98	0.77
56	0.72	0.88	0.78	0.88	0.85	0.88	0.92	0.88	1.11	0.71

Table 8 Average daily gain (kg) of calves fed experimental experimental milk replacer and starter compared with NRC estimation of ADG with the same nutrient intake at different temperatures

	NRC ADG growth prediction at different temperatures								Actual starter intake and ADG	
Day	NRC est. 5 °C		NRC est. 10 °C		NRC est. 15 °C		NRC est. 20 °C		Daily Starter Intake (kg)	Actual ADG
	Energy Allowable ADG	ADP Allowable Gain	Energy Allowable ADG	ADP Allowable Gain	Energy Allowable ADG	ADP Allowable Gain	Energy Allowable ADG	ADP Allowable Gain		
7	Weight loss	Weight loss	0.10	0.29	0.18	0.29	0.26	0.29	0.02	-0.20
14	0.06	0.31	0.15	0.31	0.23	0.31	0.30	0.31	0.05	-0.03
21	0.16	0.36	0.24	0.36	0.31	0.36	0.38	0.36	0.15	0.18
28	0.30	0.44	0.37	0.44	0.44	0.44	0.50	0.44	0.34	0.37
35	0.41	0.53	0.47	0.53	0.54	0.53	0.60	0.53	0.54	0.53
42	0.57	0.67	0.63	0.67	0.70	0.67	0.76	0.67	0.86	0.64
49	0.61	0.74	0.67	0.74	0.74	0.74	0.80	0.74	1.03	0.63
56	0.59	0.77	0.66	0.77	0.73	0.77	0.79	0.77	1.10	0.83

From week three onwards the NRC 2001 guidelines were in agreement with the growth of calves receiving experimental milk replacer and starter. The starter intake was negligible during the first two weeks of life and from week 3 onwards intake started to increase which is also in agreement with calves receiving full milk and starter. At week 3 of age the NRC estimated an energy allowable ADG of 0.30 kg/day and 0.37 kg/day at 5 °C and 10 °C respectively and the calves in the current study grew at a rate of 0.37 kg/day. It seems as if energy was the limiting factor concerning the growth of the calves. From week 5 onwards the NRC guidelines were in line with the current study's results.

From the above results it is clear that the NRC growth predictions are in agreement with the current study's growth results in particular from three weeks onwards and can be used with confidence by South African producers.

Conclusion

In conclusion, results suggest that the experimental milk replacer evaluated yielded similar growth results when compared to full milk and can therefore be successfully utilized by dairy producers. The NRC Dairy (2001) calf model compared well with the growth obtained in the current study. Prediction was lower during the first few weeks but compared favourably from week 4 onwards. The NRC Dairy could be used with confidence when predicting the growth of calves from week 4 onwards and more data is needed to evaluate the model during the early calf-feeding phase.

References

Akayezu, J.M., Linn, J.G., Otterby, D.E. & Hansen, W.P., 1994. Evaluation of calf starters containing different amounts of crude protein for growth of Holstein calves. J. Dairy Sci. 77, 1882-1889.

Coetzee, K. & Maree, D., 2007. Lactodata. The Dairy Mail, April. p. 3.

Engstrom, M., 2005. Heifers from birth to 300 lb: How important is rumen development? Proc. Mid-South Ruminant Nutrition Conference. pp. 59-65. Animal Nutrition Council, Dallas, Texas

Franklin, S.T., Sorenson, C.E. & Hammel D.C., 1998. Influence of vitamin A supplementation in milk on growth, health, concentrations of vitamins in plasma, and immune parameters of calves. J. Dairy Sci. 81:2623-2632.

Heinrichs, A.J., 1993. Raising Dairy Replacements to Meet the Needs of the 21st Century. J Dairy Sci 76, 3179-3187.

Heinrichs, A.J. & Hargrove, G.L., 1987. Standards of weight and height for Holstein Heifers. J. Dairy Sci. 70, 653-660.

Heinrichs, A.J., Jones, C.M. & Heinrichs, B.S., 2003. Effects of mannon oligosaccharide or antibiotics in neonatal diets on health and growth of dairy calves. J. Dairy Sci. 81, 2623-2632.

Hoffman, P.C., Funk, D.A. & Syverud, T.D., 1992. Growth rates of Holstein replacement heifers in selected Wisconsin dairy herds. Res. Rep. R3551. Univ. Wisconsin, Madison.

Kuhne, S., Hammon, H.M., Bruckmaier, R.M., Morel, C., Zbinden, Y. & Blum, J.W., 2000. Growth performance, metabolic and endocrine traits, and absorptive capacity in neonatal calves fed either colostrum or milk replacer at two levels. J. Animal Sci. 78, 609-920.

Larson, L.L., Owen, E.G., Albright, J.L., Appleman, R.D., Lamb, R.C. and Muller, L.D., 1977. Guidelines towards more uniformity in measuring and reporting calf experimental data. J. Dairy Sci. 60, 989–991.

Lammers, B.P., Heinrichs, A.J. & Aydin, A., 1998. The effect of whey protein concentrate or dried skim milk in milk replacer on calf performance and blood metabolites. J. Dairy Sci 81, 1940-1945.

Linn, J.G., Hutjens, M.F., Howard, W.T., Kilmer, L.H. & Otterby, D.E., 1989. Feeding the dairy herd. North Central Reg. Ext. Publ. 346. Univ. Minnesota, St Paul.

Morrill, J.L., Morril, J.M., Feyerherm, A.M. & Laster, J.F., 1995. Plasma proteins and a probiotic as ingredients in milk replacer. J. Dairy Sci. 78, 902.

Moss, R., 1998. Dairy replacement heifers – 2. Growth targets: benchmarks of performance. DPI note. File No:IL0031. Mutdapilly Research station, Queensland Government Australia

NRC, 2001. Nutrient requirements of dairy cattle. 7thh Rev. Ed. National Academy Press, Washington, DC

Quigley, J., 2005. Managing variation in calf and heifer programs. Proc. Southwest Nutr. Conf. 11-22.

Quigley, III, J.D. & Bernard, J.K., 1996. Milk replacers with or without animal plasma for dairy calves. J. Dairy Sci. 79, 1881-1884.

Quigley, J.D., III, Bernard, J.K., Tyberendt, T.L. & Martin, K.R., 1994. Intake, growth, and selected blood parameters in calves fed calf starter via bucket or bottle. J. Dairy Sci. 77, 354.

Quigley, J.D., III, Nagel, S.A. & Bernard, J.K., 1992. Intake, growth and weaning age of calves fed a preweaning supplement via bucket or bottle. The Prof. Animal Scientist 8, 17-20.

Van Amburgh, J., 2003. Calf growth and development: New requirements and implications for future performance. Proc. Southwest Nutrition and Management Conf. 18.

Van de Haar, M.J., 2004. How fast should heifers grow. Proc. Tri-State Dairy Nutrition Conf. pp. 91-106.