Milk Replacers with or Without Animal Plasma for Dairy Calves

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ABSTRACT

Holstein calves (n = 68; 40 heifers) at two locations were used to evaluate effects of the addition of plasma protein to milk replacers on growth, intake, feed efficiency, and fecal scores. Milk replacers were formulated to contain 20% CP and 20% fat. Plasma was added to milk replacers to provide 0 or 25% of CP and replaced whey protein. Calves were fed colostrum for 3 d and then milk replacer (10% of BW/d) for 56 d. Initial mean BW was 38.0 kg. Commercial calf starter was offered for ad libitum consumption throughout the study. Composition of the milk replacer had no effect on weekly BW, BW gain, intake of milk replacer or calf starter, efficiency of BW gain, or fecal scores. Mean BW gain during the 56-d study was 473 g/d, and mean BW at 56 d was 65.8 kg. Calves consumed 534 and 575 g of DM/d of milk replacer and calf starter, respectively, during the 56-d trial. Inclusion of plasma proteins at 25% of CP supported growth equal to that of whey protein.
(**Key words**: calves, milk replacers, animal plasma)

Abbreviation key: **CS** = calf starter, **MR** = milk replacer, **MRM** = MR containing milk protein, **MRP** = MR containing animal plasma.

INTRODUCTION

Milk replacers (**MR**) are widely used in the US for providing nutrients to calves prior to weaning. According to a USDA study (1), 59% of herds surveyed used MR to feed calves at least occasionally. Protein ingredients in MR contribute significantly to the overall expense of these products. Most protein in MR is provided by ingredients derived from milk, including whey protein concentrate, dried whey, and dried skim milk. Alternative sources of proteins in MR, including soybean (3, 9), fish (12), and others (13, 18), have been evaluated in MR in an effort to reduce cost. However, many alternative protein sources result in reduced performance. Recently, proteins from animal plasma have been used in early weaning starter diets for pigs (4, 6) and in MR for calves (10, 19). Plasma proteins may be attractive because of their high digestibility and favorable AA profile. The concentration of Ig in plasma may also influence intestinal colonization by enteric pathogens (2). Therefore, the objective of this study was to evaluate the use of animal plasma in MR (**MRP**) on intake, rate of BW gain, feed efficiency, and fecal scores of young dairy calves.

MATERIALS AND METHODS

Holstein heifers (n = 40) and bull calves (n = 30) at the Ames (n = 20) and Martin (n = 50) Experiment Stations were assigned randomly at birth to receive MR containing milk protein (**MRM**) or MRP. Animal plasma was included to replace 25% of the milk protein. Plasma was obtained from bovine abbatoir blood that was treated with sodium citrate, centrifuged, filtered (0.01 to 0.001 μm), and spray-dried prior to incorporation into MR. The MR (Merrick's Inc., Union Center, WI) were formulated to contain 20% CP and 20% fat and contained no antibiotics or coccidiostats. Ingredients of MRM included 28.2% dried whey, 48.9% whey protein concentrate, 20% edible lard, and 2.8% vitamins, minerals, and lecithin. Animal plasma constituted 7.5% of MRP and replaced whey protein concentrate. Both MR were formulated to provide vitamins A, D, and E and minerals to meet or exceed NRC (11) recommendations for MR. At birth, calves were fed maternal colostrum (2 L per feeding; two feedings/d) for 3 d and then were moved to individual hutches for the 56-d experiment. The MR were mixed with warm water to 12.5% DM and fed at 10% of BW/d in two feedings. Amount of MR offered was adjusted once weekly after weekly BW was determined. Commercially prepared pelleted calf starter (**CS**; Con-Agra, Inc., Omaha, NE) was fed once daily for ad libitum consumption, and orts were measured daily. Water was available at all times. Calves were weighed at the initiation of the study and every 7 d thereafter.

Received August 23, 1995.
Accepted April 5, 1996.

TABLE 1. Least squares means[1] of calf performance over the 56-d study when calves were fed milk replacer (MR) containing milk protein (MRM) or milk plus animal plasma proteins (MRP).

	Treatment			P^2		
Item	MRM	MRP	SEM	Trt	Sex	Site
Calves, no.	35	33	...	...	...	...
BW, kg						
Birth	38.3	36.5	1.2	NS[3]	0.04	0.01
28 d	46.3	44.2	0.9	0.09	NS	NS
56 d	67.3	64.3	1.4	NS	NS	0.01
Gain, 0–28 d, g/d	296	220	32	0.09	NS	NS
Gain, 28–56 d, g/d	751	717	37	NS	NS	0.01
Gain, 0–56 d, g/d	523	469	25	NS	NS	0.01
BW Gain:DMI,[4] g/kg	469	442	17	NS	NS	0.01
DMI, g/d						
Total	1146	1070	39	NS	NS	0.06
Calf starter	607	543	37	NS	NS	0.03
MR	540	528	8	NS	NS	NS
CP Intake, g/d	211	198	7	NS	NS	0.07
Fecal score[5]	1.37	1.40	0.05	NS	0.01	NS

[1]Means are adjusted by analysis of covariance for initial BW.

[2]Probability of a significant effect of treatment (Trt), sex of calf (sex), or site (Martin or Ames Experiment Stations).

[3]$P > 0.10$.

[4]Effect of interaction of treatment and site and interaction of sex of calf and site ($P < 0.10$).

[5]Effect of interaction of sex and site ($P < 0.05$). Fecal score: 1 = normal to 4 = severe scours.

Fecal scores (1 = normal fecal consistency to 4 = severe scours) were determined at the a.m. feeding (7). The CS and MR were sampled once every 2 wk and composited for analysis of DM, CP, ash, ADF (CS only), Ca, and P. Weekly intake, BW, feed efficiency, and fecal score data were analyzed as a 2 × 2 × 2 factorial arrangement of treatment, sex of calf, and site by repeated measures ANOVA (16). The BW at initiation of the study was included as a covariable. Significant ($P < 0.05$) two- and three-way interactions were included in each model. Data were pooled for the entire study and then were analyzed as a randomized complete block experimental design by ANOVA, using BW at initiation of the study as a covariable. Significance was determined at $P < 0.05$ unless otherwise noted.

RESULTS AND DISCUSSION

Two calves at the Martin Experiment Station died during the study and were not replaced. Therefore, least squares means are presented. Mean BW at the initiation of the study (3 d of age) was 38.0 kg (SE = 0.8). Calf BW at 28 d tended ($P < 0.09$) to be lower for calves fed MRP (Table 1), although BW at 56 d did not differ. Weekly least squares means of BW, BW gain, intake of CS and MR, and feed efficiency were unaffected by MR composition (Table 2).

Weekly BW and BW gain increased as age increased ($P < 0.01$); BW gain approached 900 g/d by 7 wk of age (Table 2), which is an excellent rate of BW gain for herd replacements prior to weaning. Weekly BW and BW gain were affected by an interaction of week of age and initial BW; calves with smaller initial BW did not gain as rapidly as did larger calves at a similar age. Similarly, the interaction of initial BW and week of age was significant for MR intake, total DMI, and feed efficiency. The BW gain for the 56-d experiment averaged 473 g/d (SE = 17). Morrill et al. (10) reported a BW gain of 302 and 319 g/d for calves fed MR containing bovine and porcine plasma, respectively, for 42 d. These BW gains equated to improvements of 18 and 26% over calves fed the control MR. Hansen et al. (4) reported increased BW gain when porcine plasma was included in starter diets for pigs also.

Calves in the study by Morrill et al. (10) weighed approximately 54 kg at 6 wk of the study (7 wk of age) and were fed 454 g of MR/d until weaning at approximately 35 d. That 54-kg BW was somewhat lower than the mean of 60.2 kg at 7 wk of age in the current study. However, our calves were fed more MR throughout the study (mean = 534 g/d for 56 d).

Intake of MR increased as age and BW increased, which was a function of the experimental protocol. By 8 wk, calves consumed 700 g of DM of the MR/d

(Table 2). The amount of MR consumed was affected by fecal scores; MR was replaced by electrolytes when the fecal score was ≥3. Refusals of MR were otherwise minimal and were generally related to incidence of enteric disease.

Intake of CS increased linearly as age increased (Table 2) and exceeded 1100 g/d by 8 wk. Calves were not weaned during the study but were fed MR at 10% of BW/d; therefore, CS intake was less than that reported by Morrill et al. (10), who fed a fixed amount of MR (454 g/d) and weaned calves at approximately 35 d of age. Differences between DMI of CS in this study and those of other recent reports (14, 15) were probably due to differences in amount of MR fed and type of CS offered. Calves at the Martin Experiment Station began consuming CS at an earlier age and consumed more DM from CS until wk 8 when CS intake was similar between locations.

Repeated measures ANOVA indicated a quadratic relationship between age and efficiency of BW gain. Efficiency of BW gain increased as age increased to 5 wk of age and was variable thereafter (Table 2). Increased efficiency of BW gain was probably due to a greater incidence of scours during the first 2 wk, which would reduce efficiency of BW gain, and development of intestinal digestion during the 1st wk of life (17), which would improve efficiency of BW gain as age increased. Efficiency of BW gain was unaffected by treatment, indicating that the nutrients provided from plasma did not reduce the utilization of nutrients by the calves.

Fecal scores were unrelated to treatment but were affected by an interaction of site and sex of calf. Bull calves at the Martin Experiment Station had greater fecal scores than did the others, although all calves at Martin and 13 of 20 calves at the Ames Experiment Station scoured (fecal score ≥2) for ≥1 d. Calves at Martin had a greater fecal score (1.7) than did calves at Ames (1.1), and calves at Martin scoured for a greater number of days. Fecal scores generally peaked at 1 to 2 wk of age and declined thereafter, although scores remained somewhat elevated for calves from Martin. By 3 wk of age, mean fecal scores were 1.0

TABLE 2. Least squares means (adjusted for initial BW by analysis of covariance) for BW, BW gain, intake, and feed efficiency in calves fed milk replacer (MR) containing milk protein (MRM) or milk plus animal plasma proteins (MRP).

	Age								P[1]		
Item	1 wk	2 wk	3 wk	4 wk	5 wk	6 wk	7 wk	8 wk	Trt	Sex	Site
BW,[2,3,4] kg									NS[5]	0.07	0.02
MRM	38.5	39.9	42.5	46.3	50.3	55.0	61.4	67.3			
MRP	39.2	40.3	42.3	44.2	48.7	52.9	59.0	64.3			
SEM	0.5	0.6	0.6	0.9	1.0	1.0	1.2	1.4			
BW Gain,[2] g/d									NS	NS	0.01
MRM	63	208	363	549	577	613	922	846			
MRP	170	161	275	273	644	819	871	761			
SEM	65	70	44	106	70	160	90	80			
DMI,[2,3] g.d									NS	NS	0.05
MRM	527	607	844	993	1240	1455	1619	1858			
MRP	485	561	728	958	1101	1365	1625	1890			
SEM	36	31	43	48	53	63	63	60			
MR DMI,[2,3] g/d									NS	NS	NS
MRM	425	439	473	498	534	595	640	703			
MRP	433	414	456	489	506	569	632	702			
SEM	16	14	12	10	14	14	12	14			
Calf starter DMI,[4] g/d									NS	NS	0.02
MRM	102	169	371	495	706	859	979	1155			
MRP	52	146	272	470	595	796	993	1188			
SEM	27	32	42	48	48	56	56	51			
BW Gain:DMI,[2] g/kg									NS	NS	0.01
MRM	246	468	435	535	469	420	584	475			
MRP	371	302	412	284	620	607	553	414			
SEM	105	140	60	120	60	120	56	41			

[1]Probability of a significant effect of treatment (Trt), sex of calf (sex), or site (Martin or Ames Experiment Stations).

[2]Effect of interaction of week and initial BW ($P < 0.05$).

[3]Effect of interaction of week and site ($P < 0.05$).

[4]Effect of week ($P < 0.05$).

[5]$P > 0.10$.

and 1.8 for calves at Ames and Martin, respectively. Recent reports (2) suggest that inclusion of Ig in MR may influence the health of calves exposed to challenge by *Escherichia coli*. However, the incidence and severity of scours in this study was consistent with infections by *Cryptosporidium* sp. Although this organism was not specifically isolated in this study, both farms had a history of *Cryptosporidium* infection in preweaned calves. Harp et al. (5) reported that high titers of colostral antibody specific for *Cryptosporidium parvum* were ineffective in protecting calves against challenges of *C. parvum*, although Lopez et al. (8) indicated a positive relationship between shedding of *Cryptosporidium* and concentrations of Ig in serum.

Nutrient composition of the MR did not vary by treatment and averaged (DM basis) 94.6% DM, 19.3% CP, 7.5% ash, 1.0% Ca, and 0.8% P for MRM and 93.1% DM, 19.4% CP, 8.2% ash, 0.9% Ca, and 0.9% P for MRP. Chemical composition of CS was 91.0% DM, 17.6% CP, 11.9% ADF, 8.7% ash, 1.7% Ca, and 0.8% P. The CS fed at each location was obtained from the same source; no variation in CS composition was observed between locations.

The lack of treatment effect on weekly BW gain, intake, and feed efficiency (Table 2) indicated that plasma proteins may contribute up to 25% of CP of the overall protein in MR for the preweaned calf. Hansen et al. (4) concluded that porcine plasma was superior to skim milk in starter diets of pigs and that plasma had a positive influence on growth and intake. Our data suggested that plasma protein supported BW gain in a fashion similar to whey protein.

Recent evidence (2) suggests that inclusion of Ig in MR may reduce the incidence of scours and improve animal performance. However, MRP did not influence the incidence or severity of scours at either location in this study. Further data are required to determine conditions that influence the effectiveness of dietary Ig on enteric disease.

CONCLUSIONS

Plasma proteins added to MR supported intake and rates of BW gain similar to those for MRM. In all cases, BW gain and intake of MR and CS in calves fed MRP were similar to those of calves fed MRM. Inclusion of plasma protein in MR formulations depends on economy and necessary supplementation to ensure proper AA balance. There was no evidence of an improvement in fecal scores or days scouring when MRP was fed.

ACKNOWLEDGMENTS

Appreciation is expressed to H. Moorehead, R. Carlisle, H. Henderson, and A. Woldeghebriel for assistance with care and feeding of the calves; K. Martin, L. Miller, and E. Jarboe for assistance with laboratory analyses; and Merrick's, Inc. for manufacturing MR.

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