

NUTRITION, FEEDING, AND CALVES

Effects of a Colostrum Replacement Product Derived from Serum on Immunoglobulin G Absorption by Calves

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ABSTRACT

Calves are born hypogammaglobulinemic and rely on immunoglobulin (Ig) from colostrum to obtain passive immunity. Previous research has indicated that colostrum supplements derived from milk are less effective than is maternal colostrum in providing adequate IgG to neonatal calves. Our objective was to determine the absorption of IgG by newborn calves fed a USDA food-grade colostrum supplement derived from bovine serum or fed pooled maternal colostrum. Holstein calves ($n = 20$; 10 bulls) were removed from the dam within 1 h of birth and were housed in individual stalls for the 24-h study. Calves were fed 2 L of colostrum or colostrum replacer at 1.5 and 13.5 h (± 0.1 h). Calves were blocked by colostrum pool, and replacer was fed to provide equal intakes of IgG within blocks. Jugular blood was collected at 1 and 24 h (± 0.1 h) for analysis of IgG by radial immunodiffusion. At 24 h, calves were injected with 1.5 ml of Evans blue dye to estimate plasma volume. Mean plasma IgG at 24 h of age was 7.3 ± 0.4 g/L and was affected by an interaction of block and treatment. Apparent efficiency of IgG absorption at 24 h was reduced when 750 g of the colostrum replacement product were fed but was increased when 266 g of colostrum replacement product were fed. Mean plasma volume was unaffected by treatment and was 3.5 ± 0.2 L or 9.1% of BW. These data indicate that efficiency of IgG absorption from the colostrum replacement product may be affected by amount of material fed. Proteins other than IgG in the colostrum replacement product might have reduced the efficiency of IgG absorption.

(**Key words:** calves, immunoglobulin, colostrum, colostrum replacer)

Abbreviation key: AEA = apparent efficiency of IgG absorption, CR = commercial colostrum replacement, MC = maternal colostrum.

INTRODUCTION

Passive immunity is critical to the survival and health of neonatal calves. Consumption of an adequate mass of IgG prior to cessation of macromolecular transport can reduce morbidity and mortality. Unfortunately, transfer of passive immunity to neonatal calves is too often inadequate (18), resulting in excessive rates of morbidity and mortality (18). Alternative means of providing IgG to calves have been evaluated (1, 4, 6, 7, 9, 10, 12, 20), and colostrum supplements or colostrum replacements (CR) are available commercially. Most products are based on whey or pooled bovine colostrum as the primary source of IgG and provide varying amounts of IgG (usually 25 to 35 g per dose). Serum IgG concentrations in calves fed CR to replace colostrum were low (6, 9, 20) or were not increased when CR was added to maternal colostrum [(MC); 1, 7, 9, 10, 20]. Conversely, Chelak et al. (4) reported acceptable absorption of IgG by calves fed reconstituted spray-dried bovine colostrum. Recently, a CR based on bovine serum IgG was developed (Lifeline™; American Protein Corp., Ames, IA). The objective of this study was to evaluate the absorption of IgG by calves fed pooled MC or colostrum from a CR derived from bovine serum.

MATERIALS AND METHODS

Maternal colostrum was obtained from donor cows and frozen until an amount had been accumulated that was sufficient for approximately five calves. The MC was thawed, pooled, frozen in 2-L plastic bags, and stored (-20°C) until use. A sample of each of the two pools of MC was evaluated for IgG by radial immunodiffusion (VMRD, Pullman, WA) prior to use. The CR was obtained in one lot and was weighed into

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individual plastic bags to provide a similar mass of IgG per feeding as 2 L of MC in each pool.

Twenty Holstein calves (10 bull calves) were removed from the dam within 1 h of birth and prior to nursing. Calves were weighed and placed in individual pens bedded with shavings in an unheated calf barn. Calves that had not been observed prior to removal from the dam were not used in the study. Calves were fed 2 L of MC or CR reconstituted in warm tap water as soon as possible after birth and 12 h later.

Blood was obtained by jugular venipuncture into evacuated tubes containing EDTA as soon as possible after birth and at 24 h of age. Plasma was separated by centrifugation (3000 × *g* for 15 min) and stored (-20°C) prior to analysis for IgG by radial immunodiffusion.

At 24 h of age, calves were injected with approximately 2 ml of 1.5% Evans blue dye to estimate plasma volume [PV; (13)]. Apparent efficiency of IgG absorption (AEA) at 24 h was calculated as plasma IgG (grams per liter) × PV (liters) ÷ IgG intake (grams) × 100.

Data were analyzed by ANOVA in a randomized complete block design using SAS (15). Significance was declared at *P* < 0.05 unless otherwise noted.

RESULTS

Because of differences in the IgG content of MC, intakes of IgG by calves in blocks 1 and 2 were approximately 150 and 53 g, respectively (Table 1). Intakes of IgG from MC by calves in blocks 1 and 2 were 37.4 and 13.3 g/L, respectively. Why the quality of colostrum was so poor in this study is unclear; colostrum was obtained randomly from donor cows in

the herd and collected without reference to the age of the cow or to other factors that might affect colostrum quality. Previous research with this herd (1) reported a mean IgG concentration of 54.3 g/L of colostrum. Possibly, some transition milk was collected and stored, which would have lowered the overall IgG concentration of the colostrum. Calves in blocks 1 and 2 were fed 750 and 266 g of CR per feeding, respectively. Analysis of CR by radial immunodiffusion indicated that the product contained 10 g of IgG/100 g of CR.

The mean BW of calves did not differ among treatments, although calves in block 2 tended (*P* < 0.10) to be heavier than calves in block 1 (Table 1). Mean BW was 39.3 ± 1.3 kg. Intake of MC and CR did not differ among calves; all calves consumed the 2 L of liquid offered at each feeding. Mean ages at each colostrum feeding did not differ among treatments and were 90.5 and 810.5 ± 0.9 min.

Plasma IgG concentration at the initial sampling (60.8 ± 1.6 min of age) was consistently below the minimum detection level of the assay and was assumed to be <1 g/L. Plasma IgG concentration at 24 h was affected by block and the interaction of block and treatment (*P* < 0.01). Plasma IgG in calves fed MC in block 1 and CR in block 2 was higher than plasma IgG in other calves (Table 1). The AEA was lower for calves fed CR in block 1 but was higher for calves fed CR in block 2. The AEA by calves fed MC did not vary by block and averaged 25%. Mean plasma volume was unaffected by treatment and was 3.5 ± 0.2 L.

DISCUSSION

Plasma IgG concentration of neonatal calves depends on many factors, the most important of which

TABLE 1. Effects of pooled maternal colostrum (MC) or a commercial colostrum replacement (CR) on IgG absorption by Holstein calves.

Item	Block 1			Block 2			<i>P</i> ¹
	MC	CR	SE	MC	CR	SE	
n	7	7	...	3	3
BW, kg	36.2	38.7	2.2	44.2	42.8	3.5	NS ²
IgG Intake, g	149.6	150.0	0.0	53.2	53.2	0.0	0.0001
Plasma IgG, g/L							
0 h ³	<1	<1	...	<1	<1	...	ND ⁴
24 h	10.7	6.5	0.7	3.3	5.0	1.0	0.006
Plasma volume, L	3.5	3.4	0.4	3.6	4.3	0.6	NS
AEA, ⁵ %	25	15	3	24	38	5	0.008

¹Probability of an interaction of block and treatment.

²*P* > 0.10.

³Prefeeding values were below the minimum value of the assay and were assumed to be <1 g/L.

⁴Not determined.

⁵Apparent efficiency of IgG absorption at 24 h.

are the mass of IgG consumed and age at first feeding (16, 17). In this study, plasma IgG concentration was greatest when calves in block 1 were fed MC because of greater IgG intake. When calves were fed a similar mass of IgG from CR, plasma IgG concentration was only 61% of the concentration measured in calves fed MC. The result was similar to results of other reports with colostrum supplement products (6, 9, 10) and indicates relatively poor AEA. However, when calves in block 2 were fed a smaller amount of CR, plasma IgG was greater than that in calves fed a similar amount of MC.

At 24 h of age, the AEA by calves fed CR varied according to the amount of material fed. The AEA was lower when calves were fed 750 g of CR but was higher when calves were fed 266 g of CR. Reduced AEA by calves fed colostrum supplements derived from milk or colostrum has been reported by some researchers (7, 10), but others (1, 9, 12) indicate little benefit from the addition of colostrum supplement products to MC. However, recent reports using Ig supplements derived from serum (3, 8) indicate that these proteins may be absorbed with efficiency equal to that of MC.

Variation in AEA with different intakes of CR in this study suggests that the amount of product fed to calves in block 1 might have impaired IgG absorption. The CR used in this study was 10% IgG; thus, calves in blocks 1 and 2 consumed 675 and 239 g of non-IgG material (primarily protein) per feeding, respectively. In a similar study, Garry et al. (6) fed one of three commercially available colostrum supplement products to neonatal calves. Calves were fed approximately 450 or 900 g of CR (depending on the product used) at each of two feedings 12 h apart. Serum IgG concentrations and predicted AEA of calves fed all colostrum supplements were lower than those of calves fed MC (6).

Besser and Osborn (2) reported a reduction in AEA at 12 h after colostrum feeding when colostrum whey was supplemented with BSA. However, efficiency of IgG₁ absorption was unaffected when acid hydrolyzed casein was added. Those researchers (2) suggested that there may be a limited capacity for macromolecular transport in the intestine of newborn calves, and the addition of non-Ig proteins may reduce the efficiency with which Ig are absorbed. This hypothesis is consistent with observations in our study.

A high correlation between solids and IgG in MC existed (14). Foley and Otterby (5) summarized several reports of colostrum composition, primarily from Holstein cows; calculated ratios of IgG to solids (grams per gram) in that report were 0.13, 0.14, and

0.11 for colostrum from the first, second, and third milkings after parturition, respectively (5). Oyeniyi and Hunter (11) also reported ratios of 0.13, 0.12, and 0.09 for the first, second, and third milkings of Holsteins, respectively. The MC fed to calves in blocks 1 and 2 of our study contained 21.05 and 16.03% DM, respectively, and ratios of IgG to solids were 0.17 and 0.08, respectively. Calves in blocks 1 and 2 fed MC consumed approximately 442 and 337 g of DM, respectively.

The ratio of IgG to solids in the CR used in this study was 0.10. The mass of solids fed to provide 75 g of IgG in block 1 (i.e., 750 g) might have saturated intestinal capacity for macromolecular absorption, thereby reducing AEA. Furthermore, none of the protein in the product used was from casein, which would have been removed from competition for absorptive sites by abomasal coagulation (19). When calves in block 2 were fed 236 g of CR, AEA was not impaired and was higher than AEA by calves in block 2 fed MC.

Most commercial colostrum supplement products contain a low percentage of IgG and a low ratio of IgG to solids. Therefore, a large amount of product containing non-IgG protein, lipid, and carbohydrate must be fed to provide sufficient IgG for adequate passive transfer of immunity. The mass of non-IgG material may impair IgG absorption by competing with binding sites in the intestine. In contrast to other reports of colostrum supplementation, Chelak et al. (4) reported similar IgG concentrations when calves were fed 3 L of MC or reconstituted spray-dried bovine colostrum. Colostrum used in that study contained 42 g of Ig/L, and aliquots were frozen or spray-dried prior to use. The ratio of Ig to solids was 0.22, which is considerably higher than that in other CR products and many samples of MC. When calves were fed 126 g of Ig in two feedings (284 g of solids per feeding) as MC or CR, AEA (estimated using 7% of BW as serum volume) were 31 and 33%, respectively. The study of Chelak et al. (4) suggests that an increase in the ratio of Ig to solids might improve absorption of Ig from colostrum products.

CONCLUSIONS

Seven hundred fifty grams of CR per feeding provided 150 g of IgG and resulted in reduced AEA and plasma IgG concentrations. Conversely, when 266 g of CR were fed to calves in block 2, AEA and plasma concentrations were greater than those for calves fed MC. The amount of solids in the CR fed to calves in block 1 might have affected absorption of IgG. Further research is needed to determine the

relationship between IgG and solids in CR and IgG absorption.

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