Short Communication: Effect of pH on Absorption of Immunoglobulin G in Neonatal Calves

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ABSTRACT

We fed newborn calves (n = 60) maternal colostrum (n = 12) or a colostral supplement product derived from edible bovine serum (n = 48). Sodium citrate was added to supplements to achieve a final pH of 7.5, 7.0, 6.0, and 5.0. Calves were fed colostrum (2 L/feeding) or supplement (454 g reconstituted in 2 L of water) at 1.2 and 12.6 h of age, which provided a total of 156 (colostrum) or 90 (supplement) g of IgG. We sampled jugular blood at 0 and 24 h of age to determine plasma IgG. Mean plasma IgG concentrations at 0 and 24 h of age were 0 and 6.7 g/L and were markedly higher in calves fed maternal colostrum compared with supplements (10.7 vs. 6.5 g/L) and were higher in Jersey vs. Holstein calves (8.5 vs. 6.1 g/L). Estimated apparent efficiency of IgG absorption was unaffected by treatment and averaged 20%. These data indicate that pH of colostral supplements between 7.5 and 5.0 do not markedly influence the efficiency of IgG absorption. (**Key words:** calves, colostrum, IgG)

Abbreviation key: AEA = apparent efficiency of IgG absorption; **CS** = colostrum supplement; **MC** = maternal colostrums.

The provision of passive immunity to neonatal calves has traditionally been accomplished by feeding sufficient amounts of maternal colostrum (**MC**) within the first 24 h of life. In recent years, sources of exogenous IgG have been developed, usually referred to as colostrum supplements (**CS**). The chemical composition of such products may affect the efficiency with which IgG are absorbed. Differences in absorption of IgG in MC due to alteration of chemical composition have been documented (4). Garry et al. (3) reported that IgG from several commercial CS were absorbed with limited efficiency. Differences in apparent efficiency of IgG absorption (**AEA**) among CS may be due to differences in ingredient composition, chemical characteristics, and amount of Ig. To our knowledge, the effects of pH of CS on AEA have not been evaluated. Therefore, the objective of this study was to determine the effects of varying pH on AEA of a CS derived from edible-grade bovine serum.

Holstein bull (n = 20) and heifer (n = 25) and Jersey bull (n = 4) and heifer (n = 11) calves at the Virginia Agricultural Experiment Station were used. Calves were used only if calving was observed to ensure that calves had no opportunity to nurse the dam. Each calf was moved to the calf barn, weighed, and was given one feeding of CS or MC as soon as possible after birth and, again, 12 h later. No other feed was offered in the first 24 h. Thereafter, calves were managed according to the normal procedures of the farm and fed commercial milk replacer twice daily.

The CS (Lifeline Calf Nutritional Colostrum Supplement, American Protein Corporation, Ames, IA) was manufactured to provide 45 g of IgG from edible-grade bovine serum. Additional ingredients (lactose, dextrose, glycine, salt, potassium chloride, magnesium sulfate, and emulsifiers) were added to make the final dose of 454 g per feeding. The normal pH of the reconstituted CS (454 g of CS in 2 L of H_2O) was 7.5; sodium citrate (0, 0.4, 2.3, and 7.0 g/dose) was added to produce final pH in reconstituted product of 7.5, 7.0, 6.0, and 5.0, respectively. All CS was reconstituted with distilled water (pH = 7). In addition, one group of calves (n = 12) were fed pooled MC, which was collected from Holstein cows on the dairy and frozen before initiation of the study. A 50-ml sample was collected and frozen (–20°C) before determination of IgG by radial immunodiffusion (Triple J Farms, Redmond, WA) following dilution with saline. Frozen MC was thawed in warm water prior to each feeding. All calves were fed by

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Table 1. Least squares means of intake and serum IgG in calves fed maternal colostrum (MC) or colostral supplement (CS).

	Treatment[1]						Contrast[2]			
Item	MC	7.5	7.0	6.0	5.0	SE	1	2	3	4
Calves, initial no.	12	12	12	12	12	. . .	. . .	. . .	. . .	. . .
Calves, final no.	9	10	10	10	11	1	NS	NS	NS	NS
BW, kg	38.8	35.6	36.2	36.8	38.0	2.6	NS	NS	NS	NS
Age at feeding, h										
First feeding	1.01	0.82	1.06	1.05	2.13	0.48	NS	0.07	NS	NS
Second feeding	12.84	12.88	13.04	12.02	12.07	0.64	NS	NS	NS	NS
IgG intake, g										
MC	156.4	0.0	0.0	0.0	0.0	. . .	. . .	. . .	. . .	. . .
CS	0.0	90.0	90.0	90.0	90.0	. . .	. . .	. . .	. . .	. . .
Plasma IgG, g/L										
0 h	0.00	0.00	0.00	0.00	0.00	0.0	NS	NS	NS	NS
24 h	10.66	6.57	6.49	5.76	7.19	0.81	0.001	NS	NS	NS
AEA, %[3]	21	19	20	17	24	3	NS	NS	NS	NS
d Treated, d 0–60	1.1	1.0	1.3	3.1	1.6	0.6	NS	NS	NS	NS

[1]Treatments: Control = 4 L of MC; 7.5, 7.0, 6.0, 5.0 = pH of CS. Calves were fed two doses of MC or CS.

[2]Contrast: 1 = MC versus CS; 2 = linear effect of pH; 3 = quadratic effect of pH; 4 = cubic effect of pH; NS = $P > 0.10$.

[3]Apparent efficiency of IgG absorption, calculated as: (Plasma IgG at 24 h × BW at birth, kg × 0.091)/IgG intake (g).

esophageal feeder to reduce variation in plasma IgG due to differences in voluntary intake.

Samples of blood were collected by jugular venipuncture into evacuated containers with potassium EDTA before first feeding and at 24 h of age. Plasma was collected by centrifugation, then frozen (–20°C) and transported to the laboratory for analysis of IgG by turbidimetric immunoassay (1).

Plasma IgG at 0 and 24 h, calculated AEA, and number of veterinary treatments per calf to 60 d were analyzed as a randomized complete block experimental design using Proc GLM of SAS (8). Date of birth was used as the blocking factor. Breed of calf was also included in the model. Sex of calf did not contribute significantly ($P > 0.05$) and was not included in any model. Orthogonal contrasts were used to determine differences between MC and all CS, and linear, quadratic, and cubic effects of pH in CS. Mortality was analyzed using chi-square analysis by Proc Logistic of SAS (8). Significance was declared at $P < 0.05$. Birth BW was evaluated in each model as a covariate, but was not statistically significant ($P > 0.05$). Therefore, unadjusted means are presented.

The MC contained 39.1 g of IgG/L and intake of IgG was 156.4 g in the first 24 h. The IgG content of CS did not differ and provided 45 g/feeding. Calves were fed at 1.3 (SE = 0.2) and 12.6 (SE = 0.3) h of age. There was a trend ($P < 0.10$) for calves fed CS with lower pH to be fed later; however, all calves were fed by 2.13 h of age. Plasma IgG concentrations at 0 h were all below the minimum concentration of the assay and were assumed to be 0 g/L. Mean plasma IgG at 24 h (Table 1) was lower in calves fed CS compared with MC ($P < 0.01$); however, the greater intake of IgG from MC was responsible for this difference. There was no effect of pH on IgG concentration in CS-fed calves at 24 h. Mean IgG in calves fed CS was 6.5 g/L. Apparent efficiency of IgG absorption did not vary (Table 1) with pH or MC. Overall concentration of plasma IgG was somewhat lower than typically observed with this CS product; previously, plasma IgG and AEA were 20 to 30% higher than in the current study (6). However, AEA and IgG of calves fed MC (21% and 10.66 g/L, respectively) were also somewhat low, suggesting that herd factors were at least partially responsible for observed differences. Use of esophageal feeding has been reported to reduce AEA in some calves (5), which also might have contributed to lower plasma IgG and AEA.

Morbidity and mortality of calves was monitored from birth to 60 d of age. Overall, mortality was 10 calves (16.7%), and was attributed to *Cryptosporidium*, rotavirus and *Escherichia coli* by necropsy. There was no effect of treatment on calf morbidity or mortality. All calves fed CS had lower plasma IgG concentrations than calves fed MC; however, morbidity and mortality were not affected by the lower concentrations of circulating IgG. Others (6) have made a similar observation when CS containing blood-derived IgG was fed. Others (9) have reported impaired immunity and reduced survival in calves with serum or plasma IgG concentrations <10 g of IgG/L.

Breed had a significant effect on most parameters measured. Jersey calves had higher IgG at 24 h (8.5 vs. 6.1 g/L; $P < 0.004$), greater mortality (33 vs. 11%; $P < 0.05$) and number of days treated (2.2 vs. 1.1; $P < 0.07$). However, AEA was similar ($P > 0.10$) between breeds (22 and 19% for Holstein and Jersey calves, respectively). Breed differences in plasma IgG concentration at similar IgG intake may be due to differences in body size and plasma volume (7).

Changes in pH did not affect IgG absorption from CS. Typically, colostrum has a pH of approximately 6.0 (2). However, pH did not appear to affect IgG absorption.

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