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TECHNICAL NOTE: Feeding colostrum with an esophageal feeder does not reduce immunoglobulin G absorption in neonatal dairy heifer calves

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ABSTRACT

Although the use of esophageal feeders is commonly recommended to aid in timely provision of colostrum to calves, there are few published studies that compare their effectiveness with other feeding methods. Therefore, newborn Holstein heifer calves (n = 40) were studied to compare total serum protein and IgG concentrations and apparent efficiency of absorption when colostrum was fed by nipple bottle or esophageal feeder. Calves were separated from their dams before suckling occurred, and a single feeding of 3.8 L of pooled colostrum was fed by 1.5 to 2 h of age using a nipple bottle, an esophageal feeder, or a combination of both. All calves received a total dose of 285 g of IgG. A jugular blood sample was collected from each calf at 0 and 24 h of age. No differences were detected (P > 0.05) between treatments in serum IgG concentration, total serum protein concentration, or apparent efficiency of absorption. Total serum protein averaged 6.4 ± 0.2 g/dL, total IgG was 24.4 ± 1.8 mg/mL, and apparent efficiency of absorption was 34.5 ± 2.9% (mean ± SEM).

Key words: colostrum, dairy calf, esophageal feeder, feeding method

INTRODUCTION

According to the USDA (2008), the mortality rate of preweaned dairy heifers is between 8 and 11%. Wells et al. (1996) reported that colostrum feeding (method, timing, and amount), time of separation from the dam, calving difficulty, and twin birth were the most important factors associated with calf mortality in the first 21 d of life. They further estimated that 31% of calf deaths in this period could be avoided by improved colostrum feeding. Colostrum may be obtained by nursing the dam; however, this has been shown to be an unreliable method of attaining passive immunity (Besser et al., 1991) and can also aid disease transmission from cow to calf. The USDA (2008) estimates that 60 to 65% of farms hand feed colostrum by nipple bottle, but this method has some limitations for weak calves and for feeding large volumes and can be time consuming if calves are not cooperative. Although only 4% of farms report using esophageal feeders as the primary method of feeding colostrum (USDA, 2008), this method can quickly deliver a known volume of colostrum and often provides larger capacity than standard 1.89-L nipple bottles. The ability to provide a large quantity of colostrum in a single feeding can increase labor efficiency by reducing the amount of time required to feed each newborn.

Although the use of esophageal feeders is commonly recommended to aid in timely provision of colostrum to calves, there are few published studies that compare their effectiveness with other feeding methods. Fluoroscopic studies have shown that although fluids administered by esophageal intubation enter the reticulum and rumen, they flow into the abomasum within minutes (Lateur-Rowet and Breukink, 1983; Chapman et al.,

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1986), and several observational studies have reported successful passive transfer in calves fed by esophageal feeder (Molla, 1978; Lateur-Rowet and Breukink, 1983; Besser et al., 1991). In another report, calves fed by esophageal feeder attained higher serum IgG concentrations at 24 h of age than did those fed by nipple bottle, but tube-fed calves were fed twice the volume of colostrum (4 L compared with 2 L) and more than double the mass of IgG (213.4 g compared with 97.4 g) provided to bottle-fed calves, making the results difficult to interpret (Kaske et al., 2005).

Adams et al. (1985) found that serum IgG concentrations in calves fed by nipple bottle or by esophageal feeder increased at the same rate after feeding and reached concentrations consistent with calf survival by 20 h after initial feeding. Godden et al. (2009) observed greater serum IgG and apparent efficiency of absorption (**AEA**) in calves fed via nipple bottle compared with esophageal feeder when 1.5 L of colostrum replacer containing 100 g of IgG was fed but no differences between feeding methods in calves fed 3.0 L of colostrum replacer containing 200 g of IgG. Because of the lack of controlled studies evaluating colostrum feeding methods, the objective of this study was to compare absorption of Ig, total serum protein concentration, and AEA in calves receiving colostrum via nipple bottle, esophageal feeder, or a combination of both.

MATERIALS AND METHODS

All experimental procedures were reviewed and approved by the Pennsylvania State University Institutional Animal Care and Use Committee. First-milking colostrum with IgG concentration >50 g/L as measured by colostrometer (Biogenics, Mapleton, OR) was collected from Holstein cows into new 1.89-L plastic containers and frozen at −20°C until it was needed. Once 156 L was collected, colostrum was thawed at 4°C for 24 h and then pooled. Subsamples from the pooled colostrum were taken into sterile, 15-mL, screw-cap centrifuge tubes and stored at −20°C for later analysis. Newborn Holstein heifer calves (n = 40) were separated from their dams before suckling occurred and received a single 3.8-L feeding of the colostrum by 1.5 to 2 h of age. Each calf was initially offered a nipple bottle, and if the calf refused to nurse, the remaining colostrum was fed by esophageal feeder. Thus calves were fed by nipple bottle, esophageal feeder, or a combination of both. Amounts fed by each method were controlled to establish 5 feeding-method treatments: 3.8 L via nipple bottle, 2.84 L via nipple bottle and 0.95 L by esophageal feeder, 1.89 L by nipple bottle and 1.89 L by esophageal feeder, 0.95 L via bottle and 2.84 L by esophageal feeder, and 3.8 L via esophageal feeder. Twin calves or calves whose birth required veterinary assistance were not used in this trial. A jugular blood sample was collected from each calf at 0 and 24 h of age. Serum total protein concentration was determined using a hand-held refractometer (VET 360, Reichert Inc., Depew, NY). Serum concentrations of IgG_1 and IgG_2 were determined by immunoprecipitation using single radial immunodiffusion (VWRD Inc., Pullman, WA). Serum samples (3 μL) were applied to serial radial immunodiffusion plates containing agarose gel with anti-bovine IgG. Plates were left undisturbed for 20 h at room temperature after samples were added. Resulting ring diameters were measured with a monocular comparator (VMRD Inc.), and IgG content of samples was calculated by regression analysis. A standard curve was generated with reference sera supplied by the manufacturer. Colostrum samples were also analyzed for ash, DM (AOAC, 1990), CP (Leco FP-528 Nitrogen Combustion Analyzer, Leco, St. Joseph, MI), and crude fat (AOAC, 2000) using a Tecator Soxtec System HT 1043 Extraction unit (Tecator, Foss NA, Eden Prairie, MN). The MIXED procedure of SAS (Version 9.1.3, SAS Inst. Inc., Cary, NC) was used to establish differences between treatments. Calf was included as a random effect in the model, and significance was declared at $P < 0.05$.

RESULTS AND DISCUSSION

Composition of pooled colostrum fed to all calves is shown in Table 1. All calves received 3.8 L of colostrum and 285 g of IgG. Approximately one-third of the calves in this study (32.5%) consumed 3.8 L of colostrum from a nipple bottle. The remaining calves were evenly distributed among the other feeding-method treatments. No differences were detected in any of the blood parameters measured at 0 h (data not shown) or 24 h of age (Table 2) in calves fed colostrum by nipple bottle, esophageal feeder, or a combination of both, and calves on all treatments experienced successful passive transfer of immunity. Total serum protein averaged 6.4 ± 0.2 g/dL, total IgG 24.4 ± 1.8 mg/mL, and AEA 34.5 ± 2.9% (mean ± SEM). In this study where all calves received a large volume of high-quality colostrum and colostrum volume and IgG mass were the same for all calves, feeding method had no effect on transfer of passive immunity.

Rather than being assigned to treatments randomly, calves self-selected their feeding method treatment based on the amount of colostrum they consumed from the nipple bottle. This could potentially introduce bias in the results due to interactions between the willingness of the calf to nurse and physiological states, such as

Table 1. Composition and characteristics of colostrum fed to calves

Item	Amount
IgG, g/L	74.92
Density	1.063
pH	6.10
DM, %	25.90
Fat, %	6.30
Protein, %	14.98
Lactose, %	3.30
Total solids, %	32.22
Ash, %	4.30

Table 2. Description of treatments and blood parameters at 24 h of age in calves fed colostrum by nipple bottle, esophageal feeder, or a combination of both

	Treatment					
Item	1	2	3	4	5	SEM
Number of calves	13	6	7	7	7	
Amount fed, L						
Nipple bottle	3.80	2.84	1.89	0.95	0.00	
Esophageal feeder	0.00	0.95	1.89	2.84	3.80	
IgG_1, mg/mL	22.3	23.4	23.8	22.8	24.6	1.73
IgG_2, mg/mL	1.2	1.2	1.3	1.2	1.2	0.08
Total IgG, mg/mL	23.4	24.5	25.2	24.0	25.8	1.79
Total serum protein, g/dL	6.3	6.6	6.5	6.6	6.3	0.2
AEA,[1] %	35.3	34.6	35.0	31.8	35.2	2.87

[1]Apparent efficiency of absorption.

acidosis or stress, that might influence IgG absorption. However, this method of determining feeding method reflects on-farm protocols that direct calf care personnel to offer a bottle first and tube feed any remaining colostrum.

Findings of this study are consistent with those of Adams et al. (1985), where investigators administered colostrum in 3 feedings (within 1 h after birth and at 12 and 24 h afterward; 10% of metabolic BW fed each time) either by nipple bottle or esophageal feeder and observed that calves in both groups achieved adequate passive transfer. Concentration of IgG was reported to be slightly higher in the blood of calves fed by nipple bottle, but the difference was not deemed to be of practical importance, presumably because both groups had serum IgG >12 mg/mL by 20 h after birth.

The results are also in agreement with those of Godden et al. (2009), who observed no differences in serum IgG and AEA in calves fed 3.0 L of colostrum replacer containing 200 g of IgG via nipple bottle or esophageal feeder. Godden et al. (2009) also observed that calves fed 100 g of IgG in 1.5 L of colostrum replacer had lower serum IgG and AEA when fed by esophageal feeder compared with feeding by nipple bottle. Based on these observations, the authors concluded that esophageal feeders were more effective with large volumes of colostrum (Godden et al., 2009). Calves in the present study were fed a larger volume of colostrum and a larger mass of IgG than either treatment in the Godden study.

In a study designed to determine the amount of IgG required to achieve successful passive transfer (defined as serum IgG of 13.40 mg/mL) in calves fed by esophageal intubation, Chigerwe et al. (2008) fed calves 1, 2, 3, or 4 L of colostrum in a single feeding at 2, 6, 10, 14, 18, or 22 h after birth. Using regression analysis, Chigerwe et al. (2008) found 153 g of IgG resulted in optimum passive transfer for calves fed 3 L at 2 h after birth. The amount of IgG required increased as calf age at feeding increased. Total IgG provided to tube-fed calves in the current study as well as several other studies investigating feeding method has exceeded 153 g (Kaske et al., 2005, Godden et al., 2009). Intake of IgG was not reported by Adams et al. (1985), but if a BW of 36 kg is assumed, total IgG intake could have ranged from 175 to 463 g depending on the batch of colostrum that was fed. In 2 cases, IgG intake was <153 g but ≥100 g (Besser et al., 1991; Godden et al., 2009). To the authors' knowledge, there are no published reports of feeding <100 g of IgG via esophageal feeder, so it is difficult to speculate on what effect feeding method may have when providing a smaller mass of IgG. It is possible that tube feeding of relatively small volumes could result in a delayed absorption of IgG as suggested by Godden et al. (2009). However, Lateur-Rowet and Breukink (1983) demonstrated that when 1.7 L of colostrum containing a barium suspension was administered by esophageal feeder, fluid began leaving the rumenoreticulum within minutes and emptied completely within 3 to 4 h. Regardless of feeding method, the key factors affecting absorption of IgG from colostrum are the same. Increasing the mass fed and reducing the time between birth and first feeding increases the expected IgG concentration in serum of calves. Choosing to provide colostrum via esophageal feeder may allow calf care personnel to consistently deliver a large quantity of IgG soon after birth, and the current study shows that feeding by nipple bottle, esophageal feeder, or a combination of both can allow successful transfer of passive immunity.

IMPLICATIONS

There were no differences ($P > 0.05$) between treatments when examining IgG concentration, total serum protein concentration, or AEA, and all treatments provided successful passive transfer of immunity. These results confirm that esophageal feeders can be used to administer up to 3.8 L of colostrum to newborn calves. Calf feeders are commonly advised to use an esophageal feeder for calves that do not voluntarily consume a full dose of colostrum from a nipple bottle. The results of this study suggest that this practice will not compromise AEA or serum protein levels in calves.

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