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Feeding heat-treated colostrum or unheated colostrum with two different bacterial concentrations to neonatal dairy calves[1]

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ABSTRACT

The objective of this study was to determine the effects of feeding heat-treated colostrum or unheated colostrum of different bacterial counts on passive transfer of immunity in neonatal dairy calves. First milking colostrum was collected from Holstein cows, frozen at −20°C, and then thawed and pooled into a single batch. One-third of the pooled colostrum was transferred into plastic containers and frozen at −20°C until needed for feeding (unheated-low bacteria). Another third was heat-treated at 60°C for 30 min and then frozen at −20°C until needed for feeding (heat-treated). The final third of colostrum was transferred into plastic containers, stored at 20°C for bacteria to grow for 24 h (unheated-high bacteria), and then frozen at −20°C until needed for feeding. A total of 30 Holstein bull calves weighing ≥30 kg at birth were systematically enrolled into 1 of the 3 treatment groups. Calves were separated from their dams at birth before suckling occurred. Before colostrum was fed, a jugular blood sample was collected from each calf. The first feeding consisted of 3.8 L of colostrum containing, on average, 68 g of IgG/L using an esophageal feeder between 1.5 and 2 h after birth. For the second and third feeding pasteurized whole milk at 5% of birth weight was fed. Blood samples were collected before colostrum feeding and at 24 and 48 h of age to determine serum total protein (STP) and IgG concentrations. Heat treatment of colostrum at 60°C for 30 min reduced colostrum bacteria concentration yet maintained colostral IgG concentration and viscosity at similar levels to the control treatment. Calves fed heat-treated colostrum had significantly greater STP and IgG concentrations at 24 h and greater apparent efficiency of absorption (AEA) of IgG (STP = 62.5 g/L; IgG = 26.7 g/L; AEA = 43.9%) compared with calves fed unheated-low bacteria colostrum (STP = 57.0 g/L; IgG = 20.2 g/L; AEA = 35.4%) or unheated-high bacteria colostrum (STP = 56.2 g/L; IgG = 20.1 g/L; AEA = 32.4%). High bacteria load in colostrum did not interfere with total protein or IgG absorption or AEA.

Key words: colostrum, IgG, serum protein, apparent efficiency of absorption

INTRODUCTION

Immunity is provided to neonatal calves by passive immunity derived from colostral Ig ingested and absorbed during the first 24 h of life (Stott et al., 1979a). However, colostrum has been identified as a potential means of transmission of infectious diseases to newborn calves and heat treatment of colostrum has been suggested as a control measure to eliminate or reduce the transfer of colostrum-borne pathogens to dairy calves (Godden et al., 2006). Recent studies on heat treatment of colostrum using 60°C for 30 min have shown great advantage in reducing the number of bacteria (Godden et al., 2006; Johnson et al., 2007), and it has also been shown that feeding heat-treated colostrum to neonatal dairy calves increases IgG absorption and, as a result, serum IgG concentration (Johnson et al., 2007; Elizondo-Salazar and Heinrichs, 2009). The mechanism for this is unknown; however, Johnson et al. (2007) hypothesized that because antibodies in colostrum can bind pathogens present in the gut before absorption can occur, by reducing the number of pathogens in heat-treated colostrum, and consequently the number of pathogens in the gut, more antibodies are potentially free for absorption. In addition, bacteria may bind nonspecific receptors on neonatal enterocytes, thus decreasing the number of receptors available for IgG uptake; therefore, by reducing the number of pathogens in colostrum, there may be more receptors available for IgG binding (James and Polan, 1978; James et al., 1981; Staley and Bush, 1985).

On this basis, we hypothesized that feeding colostrum with a high bacterial load would decrease IgG absorption and serum IgG concentration in neonatal calves. The objective of this study was to determine effects of feeding heat-treated colostrum and unheated colostrum with 2 different bacterial concentrations on passive transfer of immunity in neonatal dairy calves.

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MATERIALS AND METHODS

Colostrum Management

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 immediately at −20°C to inhibit bacterial growth. Once 126 L was collected, colostrum was thawed at 4°C for 24 h, and then pooled and mixed for 20 min in a commercial batch pasteurizer (Girton Manufacturing Co., Millville, PA) to create a unique batch. Colostrum collected did not include dams of the calves used in the study. Subsamples were taken into sterile 15-mL screw-cap centrifuge tubes and stored at −20°C for later analysis. One third of the pooled colostrum was transferred into new 1.89-L plastic containers and frozen at −20°C until needed for feeding (unheated-low bacteria colostrum). Another third was divided into two 21-L batches, and each batch was placed into a stainless steel container. The 2 containers were placed in a steam vat pasteurizer (Girton Manufacturing Co.) equipped with agitators to allow even heating of colostrum during pasteurization. Water and colostrum temperatures were monitored every 5 min. Colostrum was heated to 60°C, held for 30 min, and then cooled using an ice water bath. Subsamples were collected from the 2 containers and pooled for later analysis. Heat-treated colostrum was then transferred into new 1.89-L plastic containers and frozen at −20°C until needed for feeding (heat-treated colostrum). The final third of colostrum was transferred into new 1.89-L plastic containers and stored at 20°C for 24 h, allowing naturally occurring bacteria to grow freely (unheated-high bacteria colostrum). Subsamples were taken from containers and pooled for further analysis. Colostrum was then placed into a freezer at −20°C until needed for feeding.

Colostrum Sample Analyses

Samples of all colostrum were thawed at 4°C and examined for standard plate count (**SPC**), CNS count, environmental streptococci count (**ES**), coliform count (**CC**), gram-negative noncoliform count (**NC**), *Streptococcus agalactiae* count (**SAG**), and *Staphylococcus aureus* count (**SA**) according to Jayarao et al. (2004). Colostrum samples were mixed thoroughly by inverting the tube 20 to 25 times; 50 μL was placed on selective and nonselective media using an inoculating loop. Plate count agar was used for enumeration of SPC. Numbers of ES and SAG in colostrum samples were estimated using modified Edward's agar supplemented with colistin sulfate and oxolinic acid (Sawant et al., 2002). MacConkey's agar no. 3 (Oxoid, Basingstoke, UK) was used to determine CC and NC. Baird Parker's agar (Difco, LePont de Claix, France) was used to determine number of CNS and presence of SA. Plates for enumeration of SPC were incubated at 32°C for 48 h. Plates for enumeration of CNS, SA, ES, CC, SAG, and NC were incubated at 37°C for 48 h. Concentrations of IgG_1 and IgG_2 were determined by immunoprecipitation using single radial immunodiffusion (**RID**; VMRD, Pullman, WA). Serum samples (3 μL) were applied to serial RID plates containing agarose gel with anti-bovine IgG. Plates were left undisturbed for 20 h at room temperature after adding samples. Resulting ring diameters were measured with a monocular comparator (VMRD), 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). Colostrum samples were sent to the Agricultural Analytical Services Laboratory at the Pennsylvania State University to be analyzed for Ca, P, Mg, Na, K, Zn, Fe, Cu, S, and Mn. Samples were also sent to the Diagnostic Center for Population and Animal Health (Michigan State University, East Lansing, MI) to be analyzed for fat-soluble vitamins. Compositional analyses and characteristics of colostrum samples before and after heat treatment are presented in Table 1. Colostrum composition was similar to values reported by Kehoe et al. (2007), with no effects of treatment. A reduction in pH for the unheated-high bacterial colostrum reflected the increased concentration of ES in that colostrum.

Protocols used for this study were approved by the Pennsylvania State University Institutional Animal Care and Use Committee. Holstein bull calves from the university herd were separated from their dams 20 to 30 min after birth, before suckling occurred, and placed into 1.0- × 1.0-m holding pens until fed colostrum and then were housed in 1.0- × 2.6-m naturally ventilated, individual calf condos bedded with straw. A total of 30 bull calves weighing ≥30 kg at birth were systematically enrolled into 1 of 3 treatment groups receiving unheated-low bacteria, unheated-high bacteria, or heat-treated colostrum for the first feeding. Calf numbers per group were based on specific previous data of this nature to achieve sufficient power to test the hypothesis. Information for each dam and calf was recorded, including cow identification, date and time of calving, calving ease score (Weigel, 2002), calf identification number, treatment allocation, and age at feeding. Before colostrum was fed, a jugular blood sample