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Heat-treated (in single aliquot or batch) colostrum outperforms non-heat-treated colostrum in terms of quality and transfer of immunoglobulin G in neonatal Jersey calves

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ABSTRACT

The objective of this randomized clinical trial was to describe the effect on colostrum characteristics and passive transfer of IgG in neonatal calves when using the Perfect Udder colostrum management system (single-aliquot treatment; Dairy Tech Inc., Greeley, CO) compared with a negative control (fresh refrigerated or fresh frozen colostrum) and a positive control (batch heat-treated colostrum). First-milking Jersey colostrum was pooled to achieve 31 unique batches with a minimum of 22.8 L per batch. The batch was then divided into 4 with 3.8 L allocated to each treatment group: (1) heat-treated in Perfect Udder bag at 60°C for 60 min and then stored at −20°C (PU); (2) heat-treated in a batch pasteurizer (Dairy Tech Inc.) at 60°C for 60 min and then stored at −20°C in Perfect Udder bag (DTB; positive control); (3) fresh frozen colostrum stored at −20°C in Perfect Udder bag (FF; negative control); and (4) fresh refrigerated colostrum stored at 4°C in Perfect Udder bag (FR; negative control). Colostrum from all treatments was sampled for analysis of IgG concentration and bacterial culture immediately after batch assembly, after processing, and before feeding. Newborn Jersey calves were randomly assigned to be fed 3.8 L of colostrum from 1 of the 4 treatment groups. A prefeeding, 0-h blood sample was collected, calves were fed by esophageal tube within 2 h of birth, and then a 24-h postfeeding blood sample was collected. Paired serum samples from 0- and 24-h blood samples were analyzed for IgG concentration (mg/mL) using radial immunodiffusion analysis. The overall mean IgG concentration in colostrum was 77.9 g/L and was not affected by treatment. Prefeeding total plate counts ($\log_{10}$ cfu/mL) were significantly different for all 4 treatments and were lower for heat-treated colostrum (PU = 4.23, DTB = 3.63) compared with fresh colostrum (FF = 5.68, FR = 6.53). Total coliform counts ($\log_{10}$ cfu/mL) were also significantly different for all 4 treatments and were lower for heat-treated colostrum (PU = 0.45, DTB = 1.08) compared with fresh colostrum (FF = 3.82, FR = 4.80). Mean 24-h serum IgG concentrations were significantly higher for calves in the PU (41.0 mg/mL) and DTB (40.6 mg/mL) groups compared with FF (35.1 mg/mL) and FR (35.5 mg/mL) groups. Mean apparent efficiency of absorption of IgG was significantly higher for the PU (37%) and DTB (37%) groups compared with the FF (32%) and FR (32%) groups. Calves fed heat-treated colostrum (PU or DTB) experienced significantly improved AEA and serum IgG concentrations.

Key words: calf, colostrum, heat-treatment, passive transfer, immunoglobulin

INTRODUCTION

Colostrum is a critical source of nutrients and immune factors for newborn calves. However, colostrum can also represent one of the earliest potential exposures of dairy calves to a large variety of infectious agents including *Mycoplasma* spp., *Mycobacterium avium* ssp. *paratuberculosis*, fecal coliforms, *Salmonella* spp., and bovine leukemia virus (Steele et al., 1997; Walz et al., 1997; McGuirk and Collins, 2004). These pathogens can cause early calfhood morbidity or mortality caused by enteritis, septicemia, joint infections, or ear infections, or could contribute to chronic subclinical infections that are not clinically manifested until later in life (e.g., Johne's disease; Streeter et al., 1995; Steele et al., 1997; Walz et al., 1997). Additionally, high coliform counts in colostrum have been associated with decreased absorption of protective colostral immunoglobulins (James et al., 1981; Poulsen et al., 2002; Godden et al., 2012). In a recent nationwide survey of 67 farms in 12 states, 45.2% of colostrum samples tested had a total plate count (**TPC**) >100,000 cfu/mL (Morrill et al., 2012). Experts recommend that fresh colostrum fed to calves has a TPC <100,000 cfu/mL and a total coliform count (**TCC**) <10,000 cfu/mL (McGuirk and Collins, 2004).

One management tool to reduce colostrum bacterial counts is that of heat-treating colostrum. Repeated

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studies have demonstrated that heating colostrum to 60°C for 60 min results in a significant reduction in bacterial count, with no differences seen in IgG concentration. Reduction of bacterial count reduces pathogen exposure while enhancing the efficiency of absorption of IgG (Johnson et al., 2007; Elizondo-Salazar and Heinrichs, 2010; Donahue et al., 2012), resulting in improved calf health. In a multiherd, randomized controlled field study, calves fed heat-treated colostrum were at lower risk of treatment for scours or of treatment for illness (any cause) in the preweaning period. In that study, pathway analysis suggested that calves fed heat-treated colostrum were healthier because the heat-treatment process caused a significant reduction in colostrum coliform counts, which was associated with reduced risk for illness as a function of improved serum IgG concentrations (Godden et al., 2012).

Despite the benefits of heat-treating colostrum, it is a relatively new technique that is not yet widely adopted on commercial dairy farms. One factor potentially limiting its adoption, particularly on small to medium-sized dairies, is the fact that only 1 or 2 cows may calve on a single day. As such, only 4 or 8 L of colostrum might need to be heat-treated on a given day. However, larger commercial batch pasteurizers typically require a minimum batch size of at least 8 to 16 L. One potential solution to this problem is the development of a novel system designed to heat-treat individual 3.8-L aliquots of colostrum at a time. The Perfect Udder colostrum management system, developed by Dairy Tech Inc. (Greeley, CO), was designed to heat-treat individual 3.8-L aliquots of colostrum. Fresh colostrum is dispensed into a 3.8-L, single-use disposable bag, which is then floated in a batch pasteurizer tank of hot water or milk for heat treatment (60°C for 60 min). After processing, the heat-treated colostrum can be cooled to feeding temperature and fed directly or refrigerated or frozen for later thawing and heating using a hot water bath–style thawing unit.

Although the Perfect Udder system, first introduced in 2011, appears to be a practical approach for allowing small and medium-sized dairies to heat-treat small volumes of colostrum, the process requires validation to ensure that colostrum is properly heat-treated (i.e., protecting colostral immunoglobulins while significantly reducing bacterial counts) and that the thawing process does not damage colostral IgG. Finally, calf feeding trials are needed to verify that calves fed colostrum heat-treated using the Perfect Udder system experience the same increase in efficiency of absorption of IgG as those documented in previous studies that were fed colostrum heat-treated using a batch pasteurizer system.

The objectives of this study were to describe the effects of using the Perfect Udder colostrum management system to heat-treat bovine colostrum on (1) concentrations of bacteria and IgG in colostrum, and (2) efficiency of IgG absorption (%) and serum IgG concentrations in neonatal dairy calves fed colostrum heat-treated using the Perfect Udder system compared with a negative control group (calves fed fresh colostrum) and a positive control group (calves fed traditional batch heat-treated colostrum). A secondary objective was to investigate the effect of storing fresh colostrum by refrigeration versus freezing on colostrum characteristics and on measures of passive transfer in calves.

MATERIALS AND METHODS

Colostrum Processing and Sample Collection

Study activities were approved by the University of Minnesota Institution of Animal Care and Use Committee (IACUC). The study was conducted during the summer of 2012 on a large commercial Jersey farm in Minnesota. The 6,000-cow system had approximately 20 calvings per day. First-milking colostrum was collected within 2 h of calving and stored for 8 to 10 h in the refrigerator until a minimum batch of 22.8 L could be assembled. Thirty-one unique batches were assembled for this study. Each batch was pooled and mixed thoroughly to ensure a consistent starting aliquot was obtained. Once the colostrum was thoroughly agitated, duplicate 10-mL samples of fresh, raw colostrum were aseptically collected, labeled, and frozen at –20°C (initial batch). The batch was then divided into 4, with 3.8 L allocated to 1 of each of the following 4 treatments (Figure 1):

1. Perfect Udder system (**PU**): 3.8 L of colostrum was transferred into 1 Perfect Udder bag, and then heat-treated by floating in water in the DT-10G (38 L) batch pasteurizer (Dairy Tech Inc.) at 60°C for 60 min. Following cooling to 30°C or below, duplicate 10-mL samples of heat-treated colostrum were aseptically collected from the bag, labeled, and frozen at −20°C (PU postprocessing). The 3.8-L bag of colostrum was then frozen at −20°C for no less than 2 d before being selected for feeding. In preparing to feed, the bag was removed from the freezer and thawed in a hot water bath with water held at 48 to 51°C. Once the colostrum was warmed to feeding temperature (37–40°C), the colostrum was thoroughly agitated and duplicate 10-mL samples of thawed colostrum were aseptically collected, labeled, and frozen at −20°C (PU prefeeding).
2. Dairy Tech batch pasteurizer system (**DTB**; positive control): A minimum of 11.4 L of colostrum,