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Evaluation of on-farm tools for colostrum quality measurement

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ABSTRACT

The objectives of this study were to determine the immunoglobulin G (IgG) content of colostrum on Alberta dairy farms and to determine which on-farm tool, the colostrometer or the Brix refractometer, was more highly correlated with IgG content as determined by radial immunodiffusion (RID). Colostrum samples (n = 569) were collected between February and July 2012 from 13 commercial dairy farms in central Alberta, with herds ranging in size from 60 to 300 lactating cows. Immunoglobulin G content was determined directly by RID and indirectly by a colostrometer (specific gravity) and Brix refractometer (total solids). The Spearman correlation was used for the colostrometer and Brix refractometer data. According to RID analysis, 29.1% of the colostrum samples contained <50 mg/mL IgG. Concentrations ranged from 8.3 to 128.6 mg/mL IgG, with a median of 65.1 mg/mL. Third or greater parity cows had higher colostral IgG content (69.5 ± 1.98 mg/mL) than second parity (59.80 ± 2.06 mg/mL) or first parity (62.2 ± 1.73 mg/mL) cows. The colostrometer data were more highly correlated with RID results (r = 0.77) than were the Brix refractometer data (r = 0.64). Specificity and sensitivity were determined for the colostrometer and Brix refractometer compared with a cut-point of 50 mg/mL IgG as determined by RID. The highest combined value for sensitivity and specificity occurred at 80 mg/mL for the colostrometer (84.1 and 77.0%, respectively) and 23% Brix (65.7 and 82.8%, respectively). This study indicates that although the colostrometer data are better correlated with true IgG values, the user-friendly Brix refractometer is a more specific tool to detect colostrum of adequate quality.
Key words: colostrum, radial immunodiffusion, colostrometer, Brix refractometer, immunoglobulin G

INTRODUCTION

Dairy calves are born without any acquired immunity because there is no transfer of immunoglobulin across the placenta from the dam to the fetus (Larson et al., 1980). This means that newborn calves must acquire passive immunity through the consumption of colostral IgG (Baumrucker et al., 2010). Insufficient consumption of IgG results in failure of transfer of passive immunity (**FTP**), defined as serum IgG <10 mg/mL (Calloway et al., 2002). By far the greatest factor contributing to mortality of preweaned calves is FTP, associated with 39 to 50% of preweaned calf mortality (Margerison and Downey, 2005). Failure of transfer of passive immunity is widespread, with a prevalence of 19.2% on US farms (Beam et al., 2009) and 37.1% in Ontario, Canada (Trotz-Williams et al., 2008). The prevalence of FTP in dairy calves in Alberta, Canada, is currently unknown. Prevention of FTP is achieved by timely feeding of adequate quantities of colostrum that contains a minimum of 50 mg of IgG/mL as measured by radial immunodiffusion (**RID**; McGuirk and Collins, 2004; Godden, 2008; Beam et al., 2009). Colostral IgG concentrations vary considerably: Quigley et al. (2013) reported a range of 7.1 to 159 mg/mL, with 16% of samples containing <50 mg/mL, and Morrill et al. (2012a) reported values ranging from <1.8 to 200.2 mg/mL, with 29.4% of the samples containing <50 mg/mL. Due to the high prevalence of FTP and poor quality colostrum, dairy producers should measure colostral IgG before feeding it to calves or storing it for later use.

Measurement of colostrum quality on farm must be reliable, accurate, and easy to perform. Traditionally, a colostrometer has been recommended to determine on-farm quality (Fleenor and Stott, 1980). The specific gravity of colostrum, as measured by the colostrometer, has been shown to have a high correlation with IgG concentrations determined by RID ($R^2 = 0.699$; Fleenor and Stott, 1980). Unfortunately, the colostrometer has several drawbacks that may limit its adoption on farm: it is made of glass and therefore is fragile; it needs to be thoroughly cleaned before each use; and colostrum must be at 22°C to obtain a reliable measurement. It has recently been suggested that the Brix refractometer is a reliable tool for determining bovine colostrum IgG content, and that a value between 18 and 23% Brix is an appropriate cut-point for good quality colostrum (Chigerwe et al., 2008; Bielmann et al., 2010; Morrill et al., 2012b; Quigley et al., 2013). Although the cor-

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relation between Brix data and RID-determined IgG concentrations has been determined in previous studies (Chigerwe et al., 2008; Quigley et al., 2013), to the authors' knowledge no study has directly compared colostrum IgG concentrations determined by RID to both the colostrometer and Brix refractometer on individual cow samples. The objectives of this study were to determine whether the colostrometer or Brix refractometer is better able to determine colostrum quality compared with RID, and to determine the IgG content of colostrum on Alberta dairy farms.

MATERIALS AND METHODS

Colostrum Sample Collection and Analysis

Thirteen farms from central Alberta, Canada, participated in the study between February and July 2012. At each farm, the owner or an employee collected a 250-mL sample of first milking maternal colostrum (**MC**) before feeding the colostrum to the calf. Samples were labeled with cow identification number and date of collection and frozen at the farm at −20°C until transported to the University of Calgary, where they were stored at −80°C. The MC samples were thawed at 4°C and then warmed to room temperature. When the samples were between 20 and 22°C, they were analyzed for specific gravity using a colostrometer (JorVet Bovine Colostrometer, Jorgensen Laboratories, Loveland, CO) as described by Fleenor and Stott (1980). Briefly, samples were transferred to a clean and dry 100-mL graduated cylinder. The colostrometer was gently floated in the sample until it came to rest and IgG concentration was measured at the meniscus. This was performed twice for each sample. Total solids were measured with a digital Brix refractometer (PAL-1, Atago Co. Ltd., Bellevue, WA) following the procedure of Bielmann et al. (2010). Briefly, 2 to 3 drops of colostrum were placed on the measurement prism and left for 1 min to allow for temperature adjustment before the reading was taken. For the RID analysis, the colostrum was warmed to 42°C to ensure homogeneity and an aliquot was frozen at −80°C. The IgG content was determined at Prairie Diagnostic Services (University of Saskatchewan, Saskatoon, SK, Canada) using rabbit anti-bovine IgG (heavy and light chains) as previously described (Chelack et al., 1993). The IgG values reported refer to the sum of all IgG isotypes. Animal care and ethics approvals were obtained from the Veterinary Science Animal Care Committee at the University of Calgary, and all procedures followed the guidelines of the Canadian Council on Animal Care (2009).

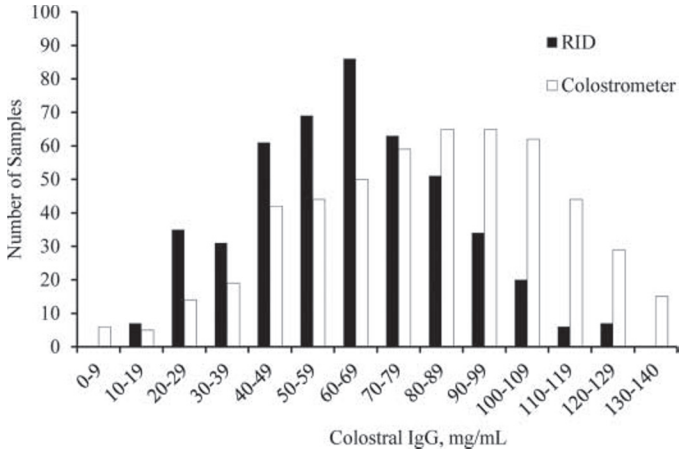

Figure 1. Distribution of radial immunodiffusion (RID) and colostrometer-determined IgG concentrations of maternal colostrum samples (n = 519 colostrometer analysis, n = 460 RID). Samples were collected from 13 farms around central Alberta, Canada.

Statistical Analysis

In total, 569 MC samples were collected. For the colostrometer analysis, 50 samples were outside of the measurement range of 0 to 140 mg/mL and were not included in the statistical analysis. The Brix refractometer had a range of 0 to 53% Brix and all 569 samples were within this range. The lower detection limit for RID analysis was 0.7 mg/mL. The samples that were analyzed were all above this lower limit; however, not all samples collected were analyzed. This study was part of a larger study in which serum IgG levels in newborn calves were measured, and so only colostrum samples that were paired with a calf serum sample were analyzed; in total, 460 samples were analyzed for IgG by RID. Consequently, all statistical comparisons between RID, Brix refractometer, and colostrometer values were made using 460 samples.

Correlation analyses to compare RID with the Brix refractometer and colostrometer data were conducted using PROC CORR of SAS (version 9.3; SAS Institute Inc., Cary, NC). The data derived from the colostrometer were not normally distributed; several transformations were attempted to improve normality parameters but none improved the correlation with RID-measured IgG values. Because the data were non-normal, the Spearman correlation coefficient was used to compare colostrometer and RID data. The Spearman correlation coefficient was also used to compare the normally distributed Brix refractometer data and the RID data to allow for statistical comparison between the on-farm tools. Sensitivity and specificity (95% CI) of the colostrometer and Brix refractometer were calculated using the RID data as the standard, with 50 mg/mL of IgG as the cut-point for adequate quality colostrum. Sensi-