Comparison of immunoglobulin G concentrations in primiparous and multiparous bovine colostrum

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ABSTRACT

Differences in Ig production were evaluated by obtaining Holstein colostrum from 3 commercial dairy herds (689 to 1,862 cows/herd) in central Pennsylvania. Colostrum was harvested from cows within 2 to 6 h postcalving, and samples were refrigerated on farms until collection by the researchers every 2 to 3 d. Data for each sample (n = 507) included cow number, lactation number, colostrum volume, and calving date. The mean concentration (mg/mL) of IgG in colostrum was affected by parity (P < 0.001) and averaged 83.5 for first lactation, 92.9 for second, 107.4 for third, and 113.3 for fourth and greater lactation. Mean IgG concentrations from all lactation groups were approximately 2 times greater than those of previous reports and exceeded 50 mg/mL, which is often considered the cut-off point for high-quality colostrum. In a subset of 133 samples, Colostrometer (Biogenics, Mapleton, OR) values were similar to actual IgG values (r = 0.67). Concentration of IgG decreased as colostrum volume increased (P < 0.001), but IgG concentration at a given level of production was variable. Mean colostrum volume was similar for all lactation groups (mean ± SD, 6.4 ± 4.1 L; P = 0.62). These results support a recommendation that all colostrum be tested for quality (IgG) without regard to lactation number or volume of first-milking colostrum. Using lactation number or colostrum volume to arbitrarily identify colostrum to be discarded may result in an unnecessary restriction of the colostrum supply, particularly if colostrum is collected soon after calving and average colostrum quality is high.

Key words: colostrum, immunoglobulin G, parity

INTRODUCTION

Past research has indicated colostrum from first-calf heifers may have reduced IgG concentration when compared with colostrum of older cows. However, most research reporting this conclusion was conducted more than 20 yr ago with a small number of samples and used single farms or university research farms with minimal description of herd health, dry cow nutrition, and vaccination protocols. Muller and Ellinger (1981) used a university herd to compare Ig levels across breeds; for the 19 Holstein cows in the study, colostrum from first parity cows averaged 26.4 mg/mL IgG compared with 55.2, 76.9, and 69.0 mg/mL for second, third, and fourth parity cows, respectively. Because of small sample numbers, more research was recommended. Oyeniyi and Hunter (1978) reported greater concentrations (41.6 and 31.4 mg/mL, respectively) of IgG in 11 samples of fourth through seventh lactation colostrum compared with 60 samples from younger cows in a university herd. Similarly, Tyler et al. (1999) collected colostrum samples from 77 Holstein cows at a university herd and found greater concentrations in third and greater lactations (97 mg/mL IgG) but no differences between first and second lactation colostrum (66 and 75 mg/mL, respectively). In another study using 87 samples (composited from the first 4 milkings) from a university herd, IgG concentrations of colostrum from first and second lactation cows were significantly less than IgG concentrations from fourth lactation and older cows (Rook and Campling, 1965). More recently, a survey of colostrum
quality in 1,017 Norwegian Red cows (Gulliksen et al., 2008) found that cows entering first or second lactation produced colostrum with less IgG than cows entering fourth or greater lactation. Few groups researching colostral Ig concentrations have specified colostrum volumes produced. Of those, Devery-Pocius and Larson (1983) reported significantly smaller volumes were produced by first lactation heifers than by other lactation groups; however, values reported were also composites of the first 4 milkings. Larson and Kendall (1957) reported significantly smaller volumes produced by first lactation heifers, but only 8 animals were used. Kruse (1970) also reported significantly smaller volumes produced by heifers collected from a total of 70 animals on a Danish experimental farm. Franklin et al. (2005) reported no differences between second and older lactations for colostrum volume in a study of 50 animals (none in first lactation). Given the limited scope of the current literature in this area and the importance of colostrum for the newborn dairy calf, the objective of this research was to evaluate IgG concentrations of colostrum and colostrum volume by lactation number using commercial dairy cows.

MATERIALS AND METHODS

Animals and Procedures

Protocols for this study were approved by the Pennsylvania State University Institutional Animal Care and Use Committee. Colostrum samples (n = 540) were obtained from Holstein cows on 3 commercial dairy herds in central Pennsylvania from September through December. All cows were milked within 2 to 6 h postcalving. Colostrum volume was measured and a 250-mL sub-sample was obtained and refrigerated. Researchers collected samples from farms every 2 to 3 d and froze colostrum at −20°C. On alternating collection days, random samples (n = 133) were warmed to 20 ± 0.5°C as described by Mechor et al. (1991) and tested using a Colostrometer (Biogenics, Mapleton, OR).

Concentrations of total IgG were determined by immunoprecipitation using single radial immunodiffusion (VWRD, Pullman, WA) and samples were validated by The Saskatoon Colostrum Co. Ltd. (Saskatoon, SK, Canada). Samples were assayed in triplicate with an allowable coefficient of variation of 10% and an R² of 98%.

Information recorded by farm personnel for each sample consisted of cow number, calving date, lactation number, total volume of first-milking colostrum, and calving ease score. Calving ease score was based on a 1 to 5 scale (1 = unassisted, 2 = moderate calving difficulty with no assistance, 3 = calving with assistance, 4 = difficult calving with heavy assistance, and 5 = veterinary assistance). Samples of TMR fed during the dry period were collected and analyzed for composition (Cumberland Valley Analytical Services Inc., Hagerstown, MD). In addition, farm management surveys were administered and information collected to identify vaccination protocols, dry cow management, and other explanatory variables differing between farms.

Statistical Analyses

Statistical analysis was conducted using the MIXED procedure in SAS (Version 9.2, SAS Institute Inc., Cary, NC). The model included the fixed effect of lactation number and the random effect of cow within farm. For analysis of IgG concentration and mass (total grams produced), colostrum volume was included as a covariate. Least squares means were compared and significance was declared at P < 0.05. The REG procedure was used to investigate the relationship between colostrum IgG concentration and volume. The CORR procedure was used to estimate the correlation coefficient of IgG concentration and volume of first-milking colostrum and IgG concentration measured via radial immunodiffusion or estimated using a Colostrometer.

A total of 540 colostrum samples were collected; however, 30 were excluded because of missing information for both colostrum volume and parity. In addition, 3 cows were reported to have produced >20 L of colostrum. These samples were removed from the data set because it was unlikely that they represented true first colostrum. Of the remaining 507 samples, some were missing lactation number or colostrum volume, but these samples were included in the analysis when possible. Parities 4 and greater were combined into a single category because there were relatively fewer animals entering their fourth or greater lactation compared with other lactation groups (parity 4 = 51, parity 5 = 31, parity 6 = 7, parity 7 = 2, parity 8 = 1, and parity 9 = 1). The final data set included 172 first lactation, 130 second lactation, 94 third lactation, 93 fourth or greater lactation cows, and 18 with no lactation number recorded.

RESULTS AND DISCUSSION

Dry cow TMR analysis and management from each farm were quite similar and generally followed recommendations (NRC, 2001) for ration composition for dry cows (Table 1). Two farms had far-off and close-up dry cow rations. Farm A diets contained slightly less CP than recommended. Diets on all farms exceeded NRC (2001) recommendations for calcium (0.44 to 0.45%), magnesium (0.11 to 0.12%), potassium (0.51 to 0.52%), iron (13 mg/kg), and manganese (16 to 18 mg/kg) for cows pregnant 240 to 270 d. Farms had some degree of heifer vaccination program and specific dry cow protocols. Previous research has indicated that nutrient availability prepartum does not significantly affect colostrum IgG content (Halliday et al., 1978; Hough et al., 1990; Santos et al., 2001). In other research, differences in colostral Ig concentrations have been observed among animals offered similar diets (Pritchett et al., 1991).

Only 10% of the samples collected in this study contained <50 mg/mL
IgG, and 43% of samples contained ≥100 mg/mL. Although the range of IgG concentrations (11 to 221 mg/mL) matched those reported by other researchers, colostrum in this study had approximately 2 times greater mean IgG concentration (96.1 ± 38.4 mg/mL; mean ± SD) than has been reported previously (Pritchett et al., 1991; Kehoe et al., 2007; Baumrucker et al., 2010). Colostrum studied was collected within 2 to 6 h after calving, which may contribute to the greater than expected concentrations of IgG (Morin et al., 2010). In addition, the present farms had documented above-average dry cow nutrition, management, and vaccination programs as well as a calving management employee to help support quality colostrum production.

Colostrum IgG concentration and total mass of IgG were affected by lactation number (P < 0.001), and the covariate of colostrum volume was highly significant (P < 0.001) for both measures of colostrum IgG. Least squares means of IgG concentration were greater in cows entering their third or fourth and greater lactation than in cows entering their first or second lactation (Table 2). This is consistent with a study by Tyler et al. (1999) and similar to the observations of Pritchett et al. (1991). However, mean IgG concentration in all lactation groups exceeded 50 mg/mL, which would be considered an indication of high-quality colostrum. Gulliksen et al. (2008) also observed greater IgG concentration in colostrum produced by cows entering fourth or greater lactation compared with that of first or second lactation cows, with mean IgG concentration for all parity groups, except second, exceeding 50 mg/mL. Total mass of IgG produced in the current study increased from first lactation through fourth and greater lactation (Table 2).

Although first-milking colostrum volume affected both concentration and mass of IgG, mean colostrum volume was similar across all lactation groups (P = 0.62) because of variability between animals. These results are similar to a report by Franklin et
al. (2005) in which no differences were observed between second lactation and older parities in colostrum production. Older studies that reported colostrum volume found first lactation cows produced less colostrum (Larson and Kendall, 1957; Kruse, 1970; Devery-Pocius and Larson, 1983). Differences between the current study and these older reports could be due to increased attention to heifer nutrition before calving and greater milk production in modern dairy cows.

Colostrum volume was negatively correlated to IgG concentration ($r = -0.16$), and regression analysis showed there was a relationship between colostrum volume and IgG concentration ($P < 0.01; R^2 = 0.03$). Although IgG concentration declined as colostrum volume increased, there was considerable variation among cows in IgG concentration at any given volume of colostrum (Figure 1). Morin et al. (2010) reported a negative relationship between colostrum volume and IgG concentration using regression analysis (IgG logarithmically transformed; $R^2 = 0.11$), and Pritchett et al. (1991) reported a correlation coefficient of $-0.29$. Baumrucker et al. (2010) reported no relationship between colostrum volume and IgG concentration. In the current study, adding lactation number to the model improved $R^2$ slightly (0.12) but still did not account for much of the variability in IgG. When the relationship of IgG concentration and colostrum volume was analyzed separately for each lactation group, there was no relationship found for first or second lactation cows ($P > 0.05$), but for third or fourth and greater lactations, the model was significant ($P < 0.01$). This suggests that measurement of colostrum IgG concentration may be even more important when the colostrum is produced by young cows and that herds with a policy of discarding colostrum from heifers may be unnecessarily limiting their supply of colostrum. In addition, decisions to discard colostrum based solely on a volume criterion may also result in an artificial restriction of the colostrum supply. In the subset of 133 samples where IgG concentration was measured by radial immunodiffusion and estimated using a Colostrometer, the correlation coefficient between methods was 0.67, indicating the Colostrometer provided a reasonable estimate of actual IgG concentration in this study.

Calving ease score did not affect IgG concentration in the current study; however, there were few stressful calvings, with only 23% of calvings being scored as 3 or higher. Calving ease scores by lactation group are shown in Table 2. The transfer of immunoglobulins from serum to colostrum begins around 1 mo before calving and peaks only days before

**Table 2. Least squares means of IgG concentration and mass, colostrum volume, and calving ease score by lactation**

<table>
<thead>
<tr>
<th>Item</th>
<th>Lactation</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>IgG, mg/mL</td>
<td>83.5b</td>
<td>92.9b</td>
</tr>
<tr>
<td>IgG, g</td>
<td>532.8b</td>
<td>579.0bc</td>
</tr>
<tr>
<td>Volume, L</td>
<td>6.2</td>
<td>6.1</td>
</tr>
<tr>
<td>Calving ease</td>
<td>1.6</td>
<td>1.7</td>
</tr>
</tbody>
</table>

*a–cMeans in the same row with different superscripts differ ($P < 0.05$).

1Includes 507 samples of Holstein colostrum collected from 3 Pennsylvania farms.

2Lactation number was not known for 18 samples.

3n = 466; first-milking colostrum volume was not known for 41 samples.

4Calving ease based on a score of 1 through 5: 1 = no assistance, 5 = veterinary assistance.

![Figure 1](image_url)
calving (Larson, 1958), indicating that stress caused by dystocia should not affect colostrum content.

**IMPLICATIONS**

In this study, IgG concentration was shown to be greater in colostrum from cows in third or greater lactation than in colostrum from first and second lactation cows. However, mean IgG concentrations from all lactation groups were approximately 2 times that of previously reported values and exceeded 50 mg/mL, which is often considered the cut point for quality colostrum. Concentration of IgG decreased as colostrum volume increased, but IgG concentration at a given level of production was variable. These results support a recommendation that all colostrum be tested for IgG level without regard to lactation number or volume of first-milking colostrum. Using lactation number or colostrum volume to arbitrarily identify colostrum to be discarded may result in an unnecessary restriction of the colostrum supply, particularly if colostrum is collected soon after calving and average colostrum quality is high.

**LITERATURE CITED**


