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Peripartal progesterone and prolactin have little effect on the rapid transport of immunoglobulin G into colostrum of dairy cows

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ABSTRACT

Colostrum formation and lactogenesis in the mammary gland and the timing of parturition are regulated by endocrine signals. Changes in progesterone (P4) and prolactin (PRL) are considered key events that inhibit colostrum formation, trigger parturition, and signal the onset of lactation. The goal of our study was to determine if colostrum yield and composition and immunoglobulin transfer are affected by prepartum milking relative to the decrease in P4, peak of PRL, or occurrence of parturition. Twenty-three multiparous cows were randomly assigned to 1 of 2 groups: (1) control with first milking at 4 h postcalving (CON, n = 11), and (2) treatment group with first milking approximately 1 d before calving and second milking at 4 h after parturition (APM, n = 12). Colostrum yields were recorded and proportional samples were analyzed for immunoglobulin G (IgG) concentration. Blood plasma samples for the analyses of P4 and PRL were collected 3 times daily at 8-h intervals for 4 d prepartum and again taken at 4 h after parturition. Total colostrum mass of APM cows was higher than that of CON cows. Immunoglobulin G concentration and protein content did not differ between antepartum milking in APM cows and postpartum milking in CON cows. Colostrum IgG concentration and protein content in APM cows at the postpartum milking were lower compared with the IgG concentration established at the prepartum (APM) and postpartum milkings of CON cows. Immunoglobulin G mass did not differ in first and second colostrum collection in APM cows but was lower compared with that of CON cows. The sum of IgG mass in APM cows (prepartum + postpartum collections) did not differ from that of CON cows. Lactose and fat in milk (concentration and mass) increased from first to second milking in APM cows. Total mass of lactose and fat in APM cows (prepartum + postpartum collections) was greater compared with that of CON cows. The finding that the time of milking relative to parturition, P4 decrease, and PRL peak slightly affected yield and quality of colostrum emphasizes the complex interactions of numerous endocrine and morphological changes occurring during colostrogenesis and lactogenesis in dairy cows. The considerably rapid transfer of immunoglobulins into colostrum of prepartum-milked cows within a few hours leads to the hypothesis that the transfer of IgG can be very fast and—contrary to earlier findings—persist at least until parturition.
Key words: colostrogenesis, colostrum, immunoglobulin G, lactogenesis, dairy cow

INTRODUCTION

Colostrum is the essential immunoglobulin source for passive immunization of the newborn calf. In modern dairy farming, colostrum is removed after parturition either directly by suckling of the newborn or by machine milking. The interval between parturition and time of first milking and ingestion of colostrum by the calf depends on various management and animal factors. Milk fever, dystocia, disturbed milk ejection, and ability of the calf to drink are examples of animal factors that affect the timely harvest and feeding of high-quality colostrum to offspring. Furthermore, the amount and quality (IgG content) of colostrum itself varies markedly in dairy cows (Baumrucker et al., 2010; Morrill et al., 2012).

Timing of parturition, lactogenesis, and colostrogenesis are regulated via endocrine signals. Changes in plasma progesterone (**P4**) and prolactin (**PRL**) concentrations are reported to be key events that mediate the initiation of parturition and onset of lactation while colostrum formation is inhibited. It is generally accepted that P4 represses peripartal lactogenesis during pregnancy and that the decrease in blood serum P4 at parturition permits the activation of mammary epithelial cells to respond to lactogenic hormones (Schams and Karg, 1969; Hoffmann et al., 1973; Convey, 1974).

It was previously reported that the prepartum increase in PRL following a decrease in P4 inhibits the

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transfer of maternal immunoglobulin (IgG) into colostrum (Guy et al., 1994b; Barrington et al., 2001). Simultaneously, the same signal triggers the onset of copious milk production (Schams and Karg, 1969; Hoffmann et al., 1973) that may dilute accumulated immunoglobulins in the mammary gland, leading to a decreased concentration of colostral IgG.

Milking before parturition is potentially a means of gaining greater IgG concentration and avoiding dilution effects through increased milk secretion (Brandon and Lascelles, 1975; Keller et al., 1977; Greene et al., 1988). In previous studies, half or whole udders of cows or goats were milked prepartum continuously until parturition, which was shown to induce a PRL response in some of the animals, resulting in the initiation of premature lactogenesis (Guy et al., 1994b). The approach of the current study was to machine milk dairy cows once before parturition (estimated 24 h) and to milk again at the usual time after parturition (4 h). Therefore, our objective was to study time of parturition, peripartum plasma progesterone and prolactin concentrations, and time-related changes in relation to colostrum yield and colostrum quality. Furthermore, we sought to identify the key effects of prepartum endocrine alterations on the appearance of colostrum components following a prepartum milking.

MATERIALS AND METHODS

Animals and Experimental Procedures

The animal experiment was conducted in accordance with the guidelines of Swiss Law on Animal Production and approved by the Veterinary Office of the Canton Fribourg, Switzerland (permit no. 2011-40-FR). The study included 23 multiparous Holstein dairy cows. Cows were transferred to straw-bedded calving pens approximately 7 d before expected parturition. Dry cows were fed hay ad libitum plus 1 kg of cereal-based concentrate and 0.5 kg of mineral supplement until calving. According to previous lactation yields (average 9,331 ± 358 kg), animals were assigned to 1 of 2 groups with an equal previous lactation performance: a control group (**CON**, n = 11) that was milked for the first time at 4 h postpartum (**p.p.**) and a prepartum milked group (**APM**, n = 12) that was first milked when sufficient milk (≥2 kg for later feeding of the calf) appeared to be available in the udder (antepartum milking, **a.p.**). The APM group was milked for the second time at 4 h p.p. Colostrum mass was recorded and proportional samples were frozen at −20°C until analysis. Starting at 7 d before expected parturition, blood samples were taken from the jugular vein 3 times daily at 0600, 1400, and 2200 h until calving, and 1 blood sample was taken 4 h after parturition (shortly before milking). Only blood samples of the last 4 d before parturition were used for analysis. Blood samples were taken in 9-mL evacuated tubes coated with EDTA and kept on wet ice until centrifugation at 2,500 × *g* for 15 min at 4°C to harvest plasma. Plasma was subsequently stored at −20°C until analysis.

Milk Sample Analysis

Colostral IgG concentration was determined with a modified ELISA (Bovine IgG ELISA Quantitation Set; Cat. No. E10-118; Bethyl Laboratories Inc., Montgomery, TX), as described previously (Lehmann et al., 2013). Results were expressed as IgG concentration in milligrams per milliliter. Milk fat, protein, and lactose contents in colostrum samples were measured by using a FTS Infrared Milk Analyzer (Bentley Instruments Inc., Chaska, MN) in the laboratory of the Milchprüfring Baden-Württemberg e.V. (Ravensburg, Germany). Masses of IgG, fat, protein, and lactose secreted by the mammary gland were calculated by multiplying respective concentrations by the corresponding milk yields.

Plasma Analyses

Plasma PRL was determined by RIA as described previously by Bruckmaier et al. (1992). For the analysis of plasma P4, a RIA kit (no. IM1188, Beckman Coulter GmbH, Krefeld, Germany) was used.

Statistical Analysis

All presented data are least squares means ± standard errors of the mean. The time of P4 decrease was defined as the time of the last sample before the concentration of P4 decreased by more than 3 standard deviations based on the fluctuations occurring during the luteal phase before the initiation of luteolysis.

The occurrence of the lactogenic PRL peak was defined as the time of sampling with a concentration of PRL elevated by more than 3 standard deviations of the previous variation of baseline PRL. To better evaluate these endocrine alterations, individual time points were clustered into 8-h blocks relative to the individual animal time to parturition for visualization and graphing purposes only.

The combined effect of milking period (a.p. vs. p.p.) plus group (APM vs. CON) on IgG concentration, IgG mass, colostrum mass, and other colostrum components was evaluated with the MIXED procedure of SAS (version 9.3; SAS Institute Inc., Cary, NC). This resulted in 3 overall treatment levels: a.p. milk from APM cows, p.p. milk from APM cows, and p.p. milk from CON

cows. Final models for colostrum mass included only milking period because the combined milking period plus group effect was not significant. The effect of cow was tested as a random effect, but only improved the model fit [lower Akaike information criterion (AIC), corrected AIC (AICC) and Bayesian information criterion] for IgG concentration and thus was not included in the final analysis of IgG mass, colostrum mass, or other colostrum components.

Of the 23 cows in the study, 19 were milked for the first time after the determined PRL peak. A separate analysis of IgG concentration, IgG mass, and colostrum mass from only those 19 cows was conducted. The models were identical to those described above for all 23 cows.

To evaluate how time relative to milking and parturition and measures of hormone dynamics were related to IgG concentration, IgG mass, and colostrum mass, linear and quadratic effects for these measures were fit and are reported where significant. These effects were fit as an overall effect across treatments, and subsequently as nested within treatments. This was only conducted for the analyses that included all 23 cows and not for evaluations of the 19 post-PRL peak subset.

In addition to evaluating a.p. and p.p. milkings for APM as separate events, IgG mass and colostrum mass from a.p. and p.p. milkings were combined for APM cows. Total IgG mass and total colostrum mass for APM versus CON cows was then evaluated using the MIXED procedure of SAS; P-values <0.05 were considered to be significant.

RESULTS

Colostrum Mass

First milking in APM cows was performed at 24.7 ± 7.1 h, ranging from 0.9 to 73.7 h before parturition. The second milking was conducted at 4.6 ± 0.3 h, ranging from 3.8 to 7.9 h after parturition, similar to CON cow milking (4.5 ± 0.1 h, ranging from 4.0 to 5.3 h) after parturition. Time of milking, decrease in P4, and PRL peak for APM cows and CON cows relative to parturition are shown in Figure 1. No difference in P4 or PRL time points was detected between the APM and CON cows. Concentrations of P4 and PRL that established these peaks did not differ between APM cows and CON cows (P4: $P = 0.52$; PRL: $P = 0.40$; Figure 2). Although the decrease in P4 occurred earlier [from 28.3 to 47.8 h (APM); from 17.0 to 33.0 h (CON)], the PRL peak occurred between 20.3 and 39.3 h (APM) and from 9.0 to 26.8 h (CON) relative to parturition (Figures 1 and 2).

For cows milked for the first time after the PRL peak, colostrum mass was not different in a.p. and p.p. milking (Figure 3). The colostrum mass in a.p. and p.p. milking in APM cows and CON cows was not different (Figure 3). However, the sum of colostrum mass in APM cows (a.p. + p.p. collection) was greater compared with that produced by CON cows ($P < 0.05$; Figure 3).

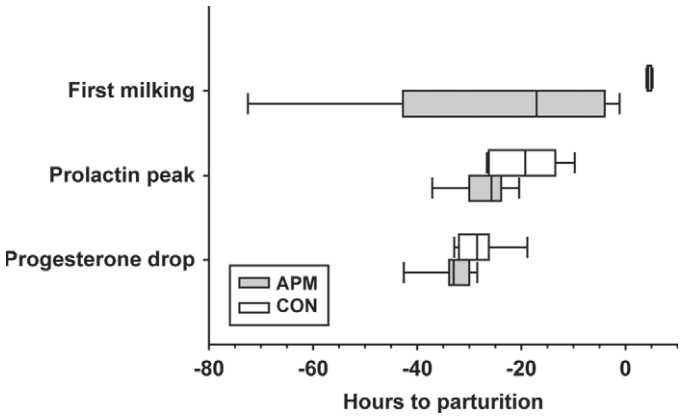

Figure 1. Time of first (APM; first milking approximately 1 d before calving and second milking at 4 h after parturition) and postpartum milking (APM and CON; control: first milking at 4 h postcalving) of cows, time of prolactin peak (h), and time of progesterone decrease (h) in all cows (APM and CON) relative to parturition. The box represents 25th to 75th percentile; whiskers show 5th to 95th percentile; line in the box indicates the median.

IgG Concentration and Mass

The concentration of IgG in a.p. colostrum of APM cows did not differ from that of CON cows but was lower in APM cows milked p.p. (Figure 4A). For cows milked for the first time after the PRL peak, IgG mass did not differ between a.p. and p.p. milked cows (Figure 4B). The p.p. concentration of IgG in milk of APM cows was lower than that of CON cows (Figure 4A). The sum of IgG mass secreted in APM cows (a.p. + p.p.) was not different from IgG mass secreted by CON cows.

Milk Fat, Protein, and Lactose Contents

Protein percentage in colostrum from a.p. milking in APM cows was not different than that of CON cows (Figure 5A). Protein percentage in milk decreased from a.p. to p.p. milking in APM cows. In contrast, protein mass was not different between APM cows (a.p. vs. p.p. milking) and not different from protein mass in milk of CON cows, but the total colostrum protein mass in APM cows (a.p. + p.p. milking) was higher compared with that secreted by CON cows (Figure 5B).

Results of lactose content (%) and mass (kg) are shown in Figure 6A and B. Colostrum lactose content

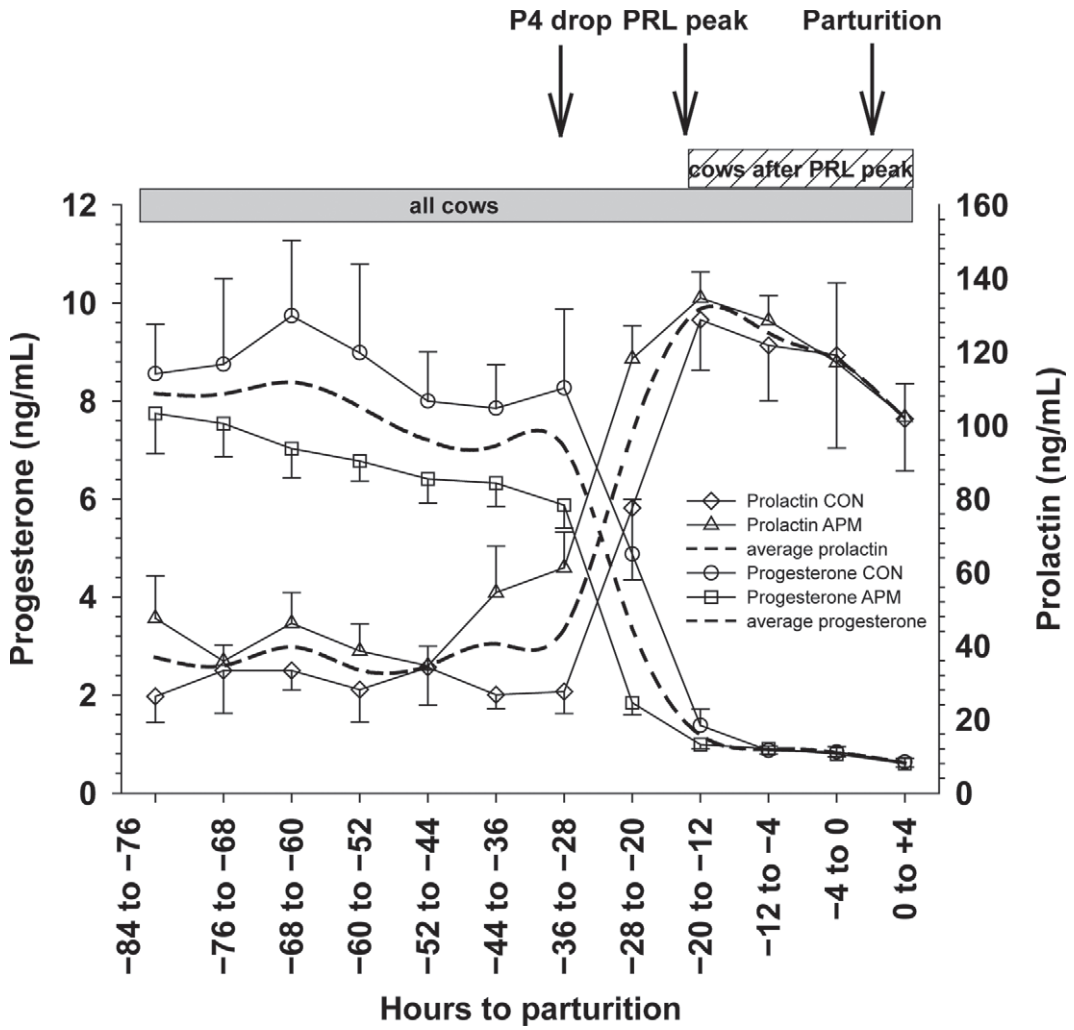

Figure 2. Profiles of plasma progesterone (P4) and prolactin (PRL) concentration for cows milked first prepartum (APM; first milking approximately 1 d before calving and second milking at 4 h after parturition) and postpartum (CON; control: first milking at 4 h postcalving). Data are means ± SEM for each clustered time point.

and mass increased in the p.p. milking of APM cows compared with a.p. colostrum lactose content and mass in APM cows. Lactose in the colostrum of CON cows was not different from that of the collections in APM cows. Interestingly, the sum of lactose mass (a.p. + p.p. milking) in APM cows was greater than the secreted lactose mass in CON cows.

Milk fat content (%) and mass increased in the p.p. milking of APM cows compared with a.p. colostrum from APM cows (Figure 7A and B). The milk fat content in the p.p. milking of APM cows was greater than that in colostrum of CON cows. Although fat mass was increased in p.p. colostrum from APM cows, it was not different from that of the colostrum in CON cows. Finally, the sum of the a.p. and p.p. fat mass from APM cows was greater than the fat mass in colostrum of CON cows.

Linear and Quadratic Effects of Time

Table 1 shows the results of the analysis of time relative to parturition on IgG colostrum concentration. We detected no linear effect on IgG concentration ($P = 0.62$), but the quadratic model indicated effects on IgG concentration in colostrum. Single treatment evaluations showed that time relative to milking had an effect on IgG concentration in colostrum for a.p. milking of APM cows, with IgG concentration increasing quadratically as parturition approached. We observed a tendency ($P = 0.05$) for IgG concentration to decrease quadratically as the time from parturition to milking increased in APM cows milked p.p. but not for the CON cows.

Table 2 shows the results of the analysis of various time and hormone dynamics on IgG mass. Posi-

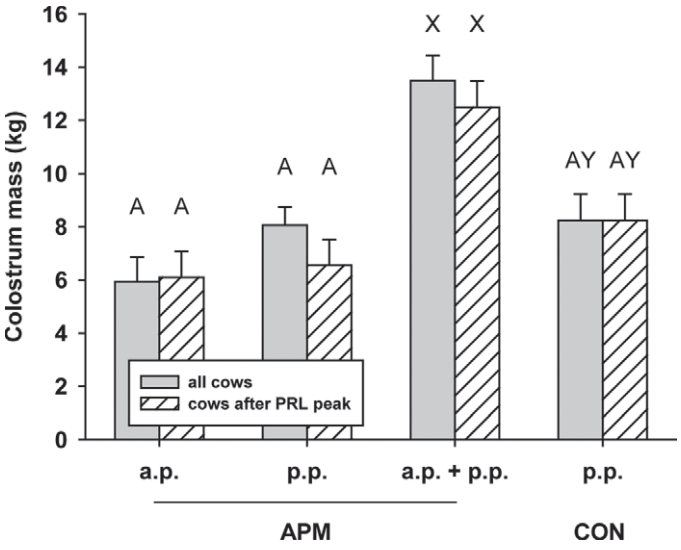

Figure 3. Colostrum mass (kg) prepartum (a.p.), postpartum (p.p.), and total (a.p. + p.p.) of cows milked for the first time prepartum (APM; first milking approximately 1 d before calving and second milking at 4 h after parturition, n = 12) or postpartum (CON; control: first milking at 4 h postcalving, n = 11). Data are least squares means ± SEM for all cows (n = 23) and cows milked after the prolactin peak (n = 19). Letters A and B indicate significant differences ($P < 0.05$) between APM (a.p., p.p.) and CON (p.p.); letters X and Y indicate significant differences ($P < 0.05$) between total milk yield (a.p. + p.p.) in APM and CON (p.p.).

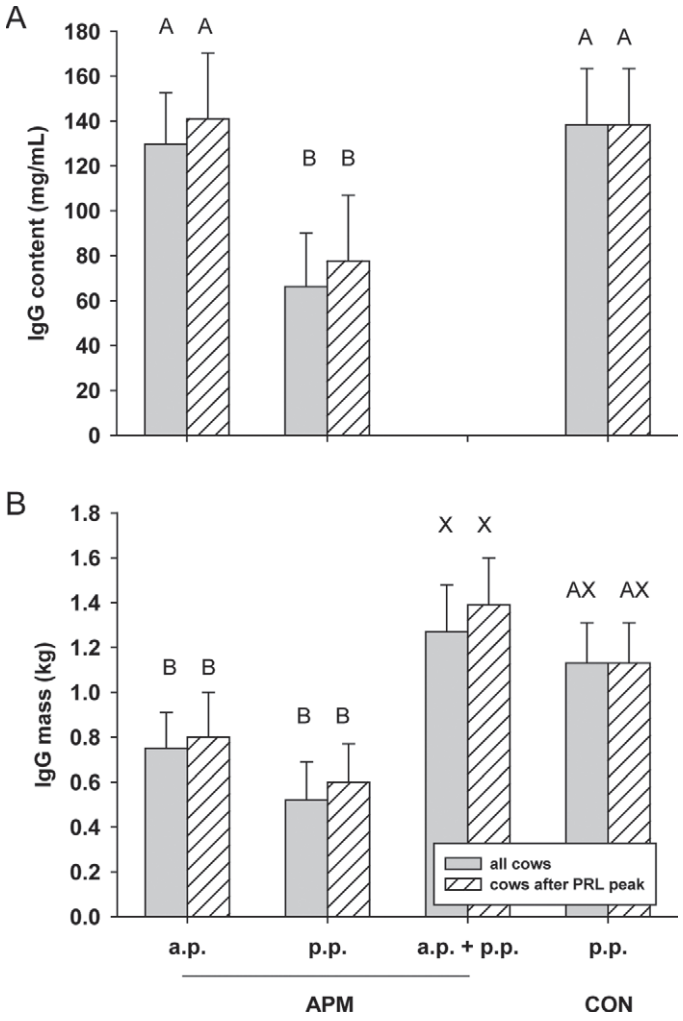

Figure 4. Immunoglobulin G concentration (A) and mass (B) of prepartum (a.p.), postpartum (p.p.), and total (a.p. + p.p.) colostrum of cows milked for the first time prepartum (APM; first milking approximately 1 d before calving and second milking at 4 h after parturition, n = 12) or postpartum (CON; control: first milking at 4 h postcalving, n = 11). Data are LSM ± SEM for all cows (n = 23) and cows milked after the prolactin (PRL) peak (n = 19). Letters A and B indicate significant differences ($P < 0.05$) between APM (a.p., p.p.) and CON (p.p.); letters X and Y indicate significant differences ($P < 0.05$) between total milk yield (a.p. + p.p.) in APM and CON (p.p.).

tive effects included P4 concentration on IgG mass of p.p. colostrum from APM cows ($P = 0.02$). The across-treatment evaluation showed that plasma PRL concentration had negative effects on IgG mass. The within-treatment analysis isolated the PRL effects to plasma PRL concentration at p.p. (ppPRL) and interval between the PRL peak and milking (PRL peak), each showing negative effects on the mass of IgG in p.p. colostrum from CON and APM cows.

DISCUSSION

The objective of this study was to collect colostrum prepartum during the later colostrogenesis period and again postpartum from the same animal to evaluate differences (from antepartum to postpartum) of colostrum mass, IgG concentration, and fat, protein, and lactose concentrations and mass under the regulation of endocrine changes during this period. Tucker (2000) noted that the main endocrine signals involved in lactogenesis are estrogen, adrenal glucocorticoids, P4, and PRL. In the present study, P4 and PRL plasma concentration changes relative to parturition were determined to represent endocrine key events in the periparturient period.

Although P4 has been shown to suppress peripartal lactogenesis (Smith et al., 1973; Vermouth and Deis, 1975; López-Fontana et al., 2012), a substantial amount of colostrum was obtained before the concentration of P4 decreased in a.p. milked cows. This indicates that colostrum IgG influx occurs during a time of high P4 plasma concentration. This finding agrees with previous work showing that colostrum forms weeks before parturition (Barrington et al., 2001).

In previous studies, prepartum colostrum mass was markedly lower (around 30% compared with the present study; Brandon and Lascelles, 1975; Keller et al., 1977) compared with the results presented here. Selection for higher milk yields over the last decades makes it difficult to dry off modern dairy cows by abrupt

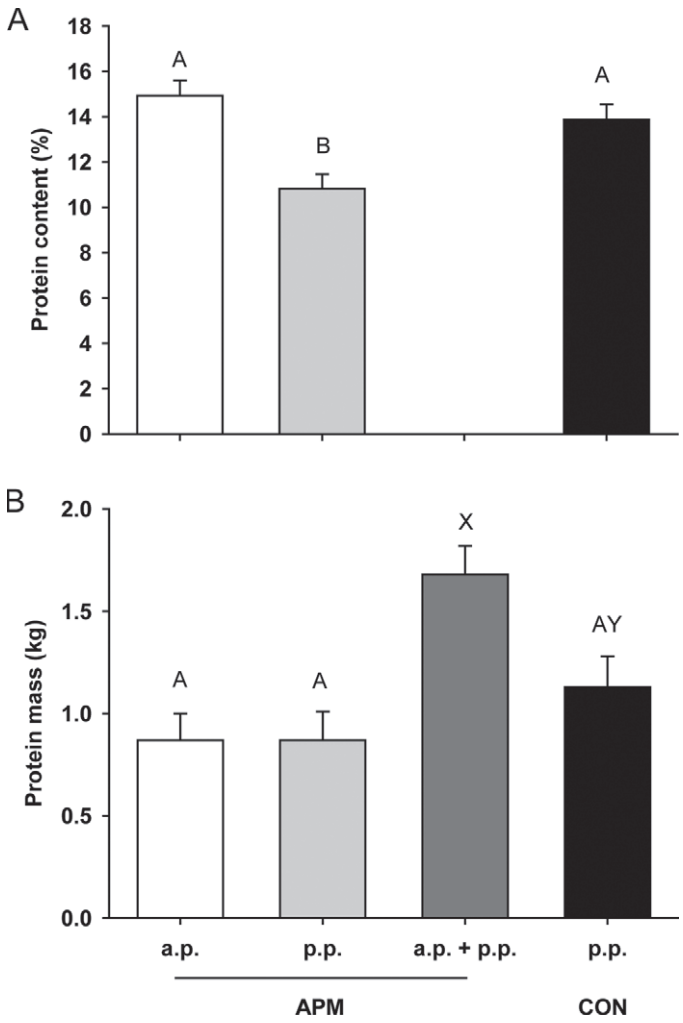

Figure 5. Protein content (A) and mass (B) of prepartum (a.p.), postpartum (p.p.), and total (a.p. + p.p.) colostrum of cows milked for the first time prepartum (APM; first milking approximately 1 d before calving and second milking at 4 h after parturition, n = 12) or postpartum (CON; control: first milking at 4 h postcalving, n = 11). Letters A and B indicate significant differences ($P < 0.05$) between APM (a.p., p.p.) and CON (p.p.); letters X and Y indicate significant differences ($P < 0.05$) between total milk yield (a.p. + p.p.) in APM and CON (p.p.).

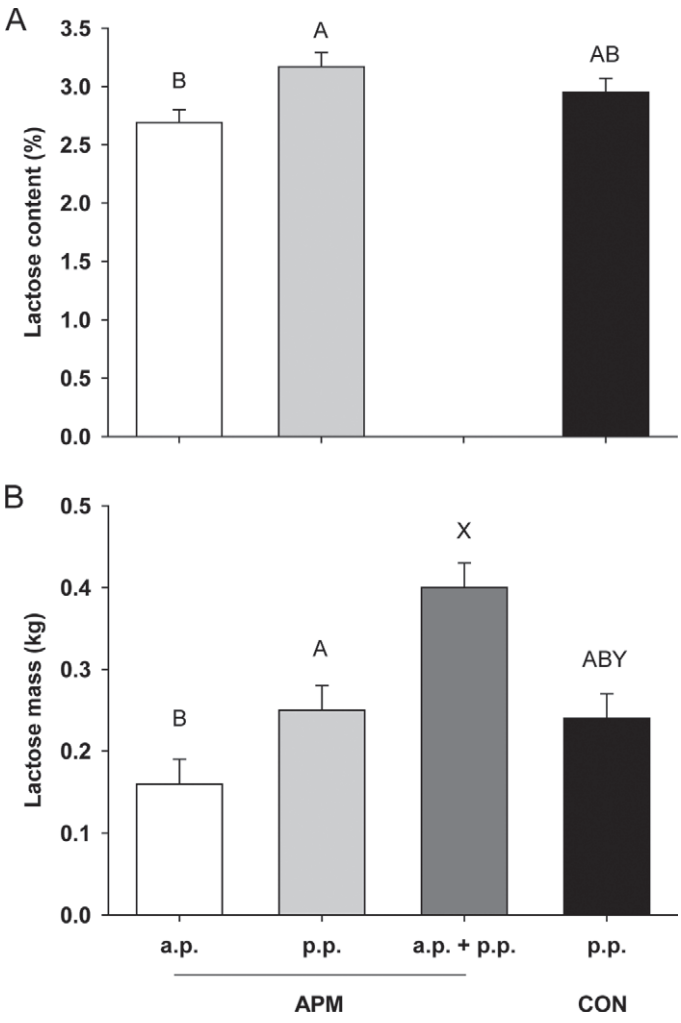

Figure 6. Lactose content (A) and mass (B) of prepartum (a.p.), postpartum (p.p.), and total (a.p. + p.p.) colostrum of cows milked for the first time prepartum (APM; first milking approximately 1 d before calving and second milking at 4 h after parturition, n = 12) or postpartum (CON; control: first milking at 4 h postcalving, n = 11). Letters A and B indicate significant differences ($P < 0.05$) between APM (a.p., p.p.) and CON (p.p.); letters X and Y indicate significant differences ($P < 0.05$) between total milk yield (a.p. + p.p.) in APM and CON (p.p.).

cessation of milking when they are producing 40 to 50 kg/d (Leitner et al., 2007). Omitting the dry period is a potential tool to overcome these problems (Zbinden et al., 2013). Therefore, it is likely that the mammary gland in today's cows, compared with that from almost 40 yr ago, undergoing a regular dry period is able to secrete considerably more colostrum before the decrease in P4.

Although we expected it to be lower, the amount of first colostrum obtained after the decrease in P4 and the PRL peak was not different compared with the mass obtained a.p. in APM cows (Figure 3). It was surprising that in such a short period, the colostrum mass (p.p.) returned to a level equivalent to that of the a.p. milking. Moreover, the sum of the 2 milkings (a.p. + p.p.) resulted in a greater colostrum mass in APM cows compared with CON cows. Some of this difference was due to the increased production of mature milk products (protein, lactose, and fat). The increased influx of water into the alveolar lumen is caused by the accelerated mass secretion of lactose (Figure 6B) and fat (Figure 7B) via osmosis.

Prepartum milking of dairy cows during late pregnancy is reported to initiate premature copious milk production in approximately 50% of cows (Rowland et al., 1953; Greene et al., 1988) by enhancing differentia-

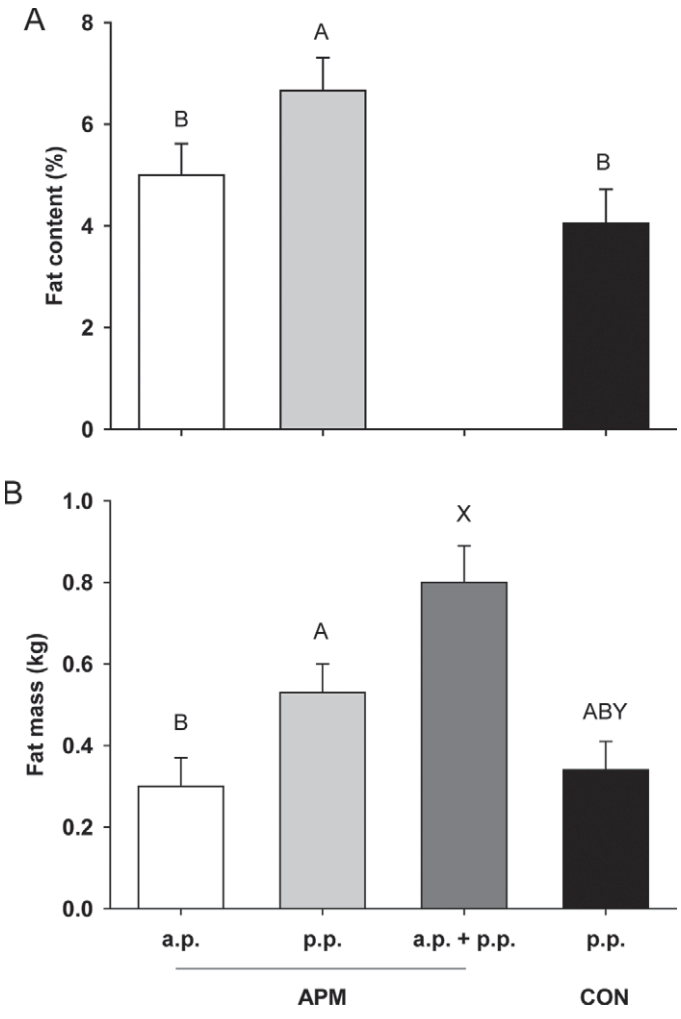

Figure 7. Fat content (A) and mass (B) of prepartum (a.p.), postpartum (p.p.), and total (a.p. + p.p.) colostrum of cows milked for the first time prepartum (APM; first milking approximately 1 d before calving and second milking at 4 h after parturition, n = 12) or postpartum (CON; control: first milking at 4 h postcalving, n = 11). Letters A and B indicate significant differences ($P < 0.05$) between APM (a.p., p.p.) and CON (p.p.); letters X and Y indicate significant differences ($P < 0.05$) between total milk yield (a.p. + p.p.) in APM and CON (p.p.).

tion and activity of mammary epithelial cells (Akers et al., 1977; Guy et al., 1994a,b). Our finding of increased lactose mass p.p. in the APM secretions supports this concept. However, if milking before parturition is performed only once and close to the time of parturition, as in the present study, it appears that the stimulating effects on copious milk production in the mammary gland are minimized and are not a strong milk secretion stimulus (Keller et al., 1977). This is evidenced by the continued appearance of IgG in the p.p. colostrum of APM cows (Figure 4A and B). Again, the presence of increased lactose mass in the p.p. colostrum sample indicates that copious milk secretion is beginning and explains the IgG concentration decrease in p.p. versus a.p. colostrum, but the recovery of equal mass of IgG shows that IgG transfer from plasma to the colostrum secretion continues at a high rate. Indeed, the statistical analysis (Table 1) showed that milking relative to parturition affected IgG concentration in colostrum and that the main effect was an acceleration of transfer (in a quadratic manner) as parturition approached during the a.p period.

The difference between colostrum IgG mass in a.p. or p.p. milking in APM cows and p.p. milking in CON cows indicates that IgG mass would continue to accumulate in the colostrum secretions if the gland were not emptied (Figure 4B). Yet the sum of the 2 milkings (a.p. + p.p.) from APM cows recovers the equivalent mass that the CON animals produce in their p.p. colostrum.

Previously, Zbinden et al. (2013) reported an increase in colostral IgG concentration 6 d before parturition in cows milked continuously until calving without any dry period. The IgG concentration remained constant at 35 mg/mL until parturition. In accordance with the present study, the P4 decrease and PRL peak did not affect the IgG concentration in prepartum colostrum. Despite continuous daily milk removal prepartum, IgG concentration was restored and did not differ from that in colostrum obtained after parturition from animals undergoing a regular dry period and without prepartum milking (Zbinden et al., 2013).

The increased secretion of lactose followed by an increased volume of secretion is thought to reflect the differentiation status and activity of mammary epithelial cells. Although the changes in lactose agree with the advance of mammary epithelial cell differentiation into copious milk production, the increased secretion of fat mass is very interesting. Apparently, prepartum milking removed the secretory product and, perhaps similar to that of 3-times-daily milking of cows during copious milk production (Klei et al., 1997), more fat secretions appeared and the sum of the 2 APM milkings provided a greater mass of fat than that of the CON colostrum. Because the secretion process of milk fat requires envelopment of the fat with milk fat globule membrane (Aoki, 2006), such a rapid secretion of fat via mechanisms that are partially known (Brownhill et al., 1985) is surprising.

Although we did not find any linear effect of the hormone changes shown in Figure 2 on colostrum IgG concentration and IgG mass, the MIXED procedure of SAS indicated that that P4 decrease in plasma had a positive effect on the appearance of greater IgG mass; the effect was quadratic, in that the P4 decrease resulted in an increasing IgG concentration as parturition approached. Another result of the MIXED model analysis was that PRL variables (Table 2) had a nega-

Table 1. Linear and quadratic coefficients of regression (b) of IgG concentration on the time of milking relative to parturition (time) within and across treatments[1]

Model	Milking	Treatment	Effect	b	*P*-value
Time					
Across treatments			Time	0.00684	0.62
Time + time^2					
Across treatments			Time	0.13894	0.009
			Time^2	0.00003	0.001
Within treatment	Postpartum	CON	Time	2.31445	0.94
	Postpartum	CON	Time^2	−0.00340	0.95
	Antepartum	APM	Time	0.16494	0.04
	Antepartum	APM	Time^2	0.00003	0.05
	Postpartum	APM	Time	−4.94089	0.07
	Postpartum	APM	Time^2	0.00698	0.07

[1]CON = control: first milking at 4 h postcalving; APM = first milking approximately 1 d before calving and second milking at 4 h after parturition.

tive effect on the appearance of IgG mass in colostrum. That is, the plasma PRL concentration had a negative effect on IgG concentration in the prepartum period across all treatments that were linear ($P = 0.01$) and quadratic ($P = 0.02$). The finding that a PRL decrease occurring postpartum had a significant effect on IgG concentration supports findings of previous studies (Smith and Schanbacher, 1973; Convey, 1974; Barrington et al., 2001). However, the effect of these hormone changes in the plasma was minimal, as evidenced by the continuation and acceleration of IgG mass into the mammary gland following prepartum milking. The one very pronounced effect upon IgG mass transfer was the occurrence of parturition, when all of the colostrum collected declined in a normal fashion with each successive milking (data not shown).

These findings conflict with our current understanding of colostrum formation. It has long been thought that the decrease in plasma P4 concentration was the key instigator of an accelerated IgG transfer from plasma to the mammary secretions (Barrington et al., 2001). Although we show an influence of P4 change in the plasma upon IgG concentrations in the mammary secretions, it is clear that the effect is somewhat minor in our experimental paradigm. Similarly, increased PRL concentrations in the plasma were thought to induce copious milk production and, at the same time, inhibit colostrogenesis. Again, our findings show a PRL effect, but similar to our P4 finding, it appears to be minimal. The dominant effect upon colostrum IgG concentration is the parturition event. The trigger of this change in IgG transcytosis is currently unknown.

Table 2. Linear and quadratic coefficients of regression (b) of IgG mass on the time of milking relative to parturition (time), time of progesterone (P4) concentration decrease (P4 drop), prolactin concentration (PRL), postpartum prolactin concentration (ppPRL), prolactin concentration decrease (PRL drop), and prolactin peak (PRL peak) within and across treatments[1]

Model	Milking	Treatment	Effect	b	*P*-value
PRL + PRL^2					
Across treatments			PRL	−43.049	0.02
			PRL^2	0.160	0.03
ppPRL + ppPRL^2					
Across treatments			ppPRL	−34.134	0.01
			ppPRL^2	0.137	0.02
Within treatments	Postpartum	CON	ppPRL	−46.454	0.05
	Postpartum	CON	ppPRL^2	0.210	0.07
PRL drop + PRL drop^2					
Across treatments			PRL drop	3.1450	0.02
			PRL drop^2	−0.001	0.02
P4 drop					
Within treatment	Postpartum	APM	P4 drop	122.636	0.02
Time + time^2					
Within treatment	Postpartum	APM	Time	−37.333	0.03
	Postpartum	APM	Time^2	0.054	0.02
PRL peak + PRL peak^2					
Within treatment	Postpartum	CON	PRL peak	13.580	0.02
	Postpartum	CON	PRL peak^2	−0.004	0.03

[1]CON = control: first milking at 4 h postcalving; APM = first milking approximately 1 d before calving and second milking at 4 h after parturition.

Like most aspects of mammary function, it is likely that mechanisms of colostrogenesis are additionally affected by local autocrine or paracrine factors within the mammary gland; for example, variation in IgG content and colostrum composition between individual quarters (Baumrucker et al., 2014). These mechanisms may act in concert with or independently of endocrine signals during colostrogenesis and lactogenesis, contributing to the high variation in colostrum yield and quality as observed in the present study.

CONCLUSIONS

Prepartum milking showed the same high animal variation in colostrum concentration and mass that has been reported for postpartum colostrum. However, the mammary gland exhibited a remarkable capacity to transfer IgG into the secretions in a relatively short period (within a few hours), recovering the same mass that was present in the previous milking. This rapid transfer was not terminated by the decrease in P4 and increased PRL peak and was accelerated until the arrival of parturition. These findings emphasize the complex interactions of numerous endocrine and morphological changes occurring during colostrogenesis in dairy cows. The narrow time frame between P4 decrease, PRL peak, and parturition seems to couple different secretory patterns of milk and colostrum components, as indicated by the rapid recovery of lactose and fat.

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