Natural Protective Factors in Bovine Mammary Secretions Following Different Methods of Milk Cessation

ABSTRACT

Bovine mammary secretions were obtained during late lactation and early involution to determine if different methods of milk cessation influenced milk yield, composition, and in vitro growth of coliform mastitis pathogens. Cows (n = 8/group) producing about 13 kg of milk prior to experimentation were dried off by abrupt or intermittent milk cessation. An additional group was dried off by intermittent milk cessation and fed only hay during the last week of lactation. Cows milked intermittently produced significantly less milk during the last week of lactation than cows dried off by abrupt milk cessation. Mammary secretions from cows milked intermittently and fed only hay contained higher concentrations of somatic cells, lactoferrin, immunoglobulin G, and bovine serum albumin, a lower citrate:lactoferrin molar ratio, and were more inhibitory to in vitro growth of *Escherichia coli* and *Klebsiella pneumoniae* throughout most of the experimental period than mammary secretions from cows dried off by intermittent or abrupt milk cessation. Few differences in mammary secretion composition or in vitro growth of mastitis pathogens were observed between cows dried off by intermittent or abrupt milk cessation. Data suggest that growth of mastitis pathogens in mammary secretions may be related to natural protective factors, which can be manipulated by different methods of milk cessation.

INTRODUCTION

The bovine mammary gland is susceptible to new intramammary infections (IMI) during the early dry period when the udder is undergoing involution (4, 7, 8, 14, 21, 22, 23). Many infections that occur at this time persist throughout the dry period and are often a major cause of clinical mastitis in the subsequent lactation, especially during early lactation. Consequently, the prevention of bovine mastitis during the dry period is important.

Reasons for increased susceptibility of mammary glands to new IMI during early involution remain unclear. However, previous reports suggest that cows producing large quantities of milk during late lactation were more susceptible to new IMI than cows producing minimal quantities of milk (11, 12). Cessation of milking at the end of lactation results in increased intramammary pressure, which may cause leakage of milk from the mammary gland and enhance bacterial penetration of the streak canal (4, 12). Furthermore, mammary secretions from glands producing large quantities of milk during late lactation may contain lower concentrations of natural protective factors such as phagocytic cells, lactoferrin, and immunoglobulins, which are related to resistance of the mammary gland to IMI (3, 10, 13, 20, 23). Thus, excess fluid volume in the udder during early mammary involution may provide an excellent medium for bacterial growth.

Intermittent milking near the time of drying off results in marked reductions in milk yield.
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(11, 12). Oliver et al. (11, 12) and Natzke et al. (6) reported that cows milked intermittently during late lactation had fewer new IMI than cows dried off by abrupt milk cessation, although methods varied considerably. Oliver et al. (12) recommended that cows dried off by abrupt milk cessation should have feed and water restricted 48 h prior to drying off to decrease milk production.

Although previous studies correlated milk yield at drying off with rate of new IMI, they did not examine changes in mammary secretion composition resulting from different methods of milk cessation. In addition, high producing dairy cows are frequently dried off while producing significantly greater quantities of milk than cows used in the previous studies. Consequently, intermittent milking may be more effective as a means of decreasing milk yield at drying off in present management systems. The objective of the study was to evaluate the effect of different methods of milk cessation on milk yield and composition during late lactation and early involution. In addition, the ability of mammary secretions to inhibit growth of coliform mastitis pathogens was determined.

MATERIALS AND METHODS

Twenty-four late lactation dairy cows were dried off approximately 8 wk prior to expected calving. Eight cows were dried off by abrupt cessation of milking (group 1). Eight cows were dried off by intermittent milking (group 2) in the following manner: all p.m. milkings were terminated 1 wk prior to drying off and both a.m. and p.m. milkings were ceased 1 d prior to drying off. A final milking occurred the day of drying off in the a.m. Eight additional cows (group 3) were dried off intermittently as described. However, these cows were fed only free choice timothy hay as soon as intermittent milking began. During the last week of lactation, cows in groups 1 and 2 were fed a total mixed ration consisting of 41 kg of a 50:50 mixture of corn silage and grass silage and 4.5 kg of a grain mixture composed of ground ear corn, soybean meal, and supplemented with vitamins and minerals. Following the last milking of lactation, cows from all treatment groups were fed a ration consisting of 35 kg of a 50:50 mixture of corn silage and grass silage.

All cows were producing about 13 kg of milk/d at 1 wk prior to drying off. During the last week of lactation, milk weights were recorded at each milking. Cows were not infused with antibiotics after the last milking of lactation.

Milk samples for bacteriological examination were collected aseptically from all quarters of cows at 14 and 7 d prior to drying off. Quarter foremilk samples were streaked (.01 ml) on plates of blood agar containing 50 ml whole calf blood/L of trypticase soy agar (BBL, Cockeysville, MD) and on MacConkey agar (Difco Laboratories, Detroit, MI). Plates were incubated at 37°C, and growth was observed and recorded at 24 and 48 h. Bacterial growth on primary culture media was identified tentatively by colony morphology and hemolytic characteristics. Staphylococcal isolates were tested for coagulase production.

A quarter was considered infected if the same pathogen was isolated from two consecutive foremilk samples. Cows free of intramammary infection by major mastitis pathogens at the onset of the study were selected.

Composite milk samples from all cows were obtained 7 (D−7) and 3 (D−3) d prior to drying off, at drying off (D−0), and 2 (D + 2), 4 (D + 4), and 7 (D + 7) d postdrying off.

Preparation of Samples

Samples were centrifuged at 48,000 × g for 20 to 30 min at 4°C to remove fat and cellular debris. A small amount of skim milk was saved and frozen at −20°C. The pH of the remaining skim milk was recorded and then decreased to 4.5 by dropwise addition of glacial acetic acid to precipitate casein. Samples were again centrifuged at 48,000 × g for 20 min to 1 h at 4°C to remove casein. Whey was stored at −20°C until analyzed.

Compositional Analysis

Numbers of somatic cells were determined by the direct microscopic somatic cell count method (9). Citrate was quantified in skim preparations using the technique of trichloroacetic acid filtrate and color-forming reactions between pyridine, acetic anhydride, and citric acid as described by Marier and Boulet (5).
The concentration of whey proteins, lactoferrin (Lf), immunoglobulin G (IgG), and bovine serum albumin (BSA) were quantified by electroimmunodiffusion on cellulose acetate plates as described by Schanbacher and Smith (18). Purified IgG and BSA were obtained from Miles Laboratories (Kankakee, IL) and Sigma Chemical Company (St. Louis, MO), respectively. Lactoferrin standards were prepared from purified bovine Lf as described by Smith et al. (19). Antiserum for bovine Lf (.5%) was prepared as described (19). Antibovine IgG (2.0%) and anti-BSA (2.0%) were obtained from Miles Laboratories (Kankakee, IL) and Antibodies, Inc. (Davis, CA), respectively.

**Microassay of Bacterial Growth**

Mammary secretions from 4 cows per treatment group were utilized to determine in vitro growth inhibition of coliform mastitis pathogens. Samples were collected 7 and 3 d prior to drying off, at drying off, and 2, 4, and 7 d after drying off.

Wheys were prepared by increasing the pH to 6.8 by dropwise addition of 1 N sodium hydroxide. All samples were plated on esculin blood agar and incubated for 48 h at 37°C to determine sterility. Approximately 10% of samples were not sterile and were filtered through a series of membrane filters (Millipore Corp., Bedford, MA) with decreasing pore size down to .45 μm. Following filtration, sterility was determined by plating samples on esculin blood agar and incubating for 48 h at 37°C. *Escherichia coli* (McDonald 487 provided by K. L. Smith, Ohio Agricultural Research and Development Center, Wooster) isolated initially from a cow with naturally occurring acute mastitis and *Klebsiella pneumoniae* (isolated from the University of Massachusetts dairy research herd) were used in the bacterial growth assay. A single colony of each bacterial type grown on blood agar was inoculated into brain-heart infusion broth (BHIB; Difco Laboratories, Detroit, MI) and incubated for 18-24 h at 37°C. Ten microliters of culture were transferred to 5 ml of BHIB and incubated until bacteria reached logarithmic growth. The bacterial suspension was centrifuged at 10,000 × g for 10 min, and the pellet was washed twice with .1% proteose peptone, suspended in .1% proteose peptone, and stored at 4°C. Numbers of bacteria were determined by serial dilution in .2 M phosphate buffer (pH 6.8), plated on MacConkey agar, incubated 10 to 12 h, and counted using an automated bacterial colony counter (Fisher Scientific Co., Medford, MA).

Inhibition of bacterial growth by mammary secretions was examined using an in vitro microtiter assay system (3, 10). Briefly, a Microtiter plate (Becton, Dickinson and Co., Oxnard, CA) containing 96 wells with a capacity of 300 μl/well was used. Bacto synthetic broth AOAC (Difco Laboratories, Detroit, MI; 17 mg/ml of H2O) and dextrose (2 mg/ml of H2O) were used in all bacterial growth assays. Each well of the microtiter plate contained 50 μl of the bacto synthetic broth AOAC and dextrose mixture and 10 μl of a bacterial inoculum containing about 100 cfu. Sterile whey (200 μl) or 200 μl sterile H2O (controls) were also added to each well. Plates were covered with a sterilized lid and incubated for 18 h at 37°C. Samples and controls were evaluated in duplicate and assays were performed under constant conditions to minimize variation.

Following incubation, 10 μl of the mixture from each well were dispensed into tubes containing 5 ml of .2 M phosphate buffer (pH 6.8) and serial dilutions were made. Ten microliters of the appropriate dilution were dispensed on MacConkey agar, plates were incubated for 12 h, and bacteria were counted using an automated bacterial colony counter.

Data were expressed as bacterial growth inhibition and calculated as follows: bacterial growth inhibition = (log_{10} cfu/ml of bacto synthetic broth AOAC-plus-dextrose mixture) − (log_{10} cfu/ml of whey supplemented with bacto synthetic broth AOAC-plus-dextrose mixture).

**Statistical Methods**

Pretreatment and posttreatment milk yield was analyzed by Student's t test. Analysis of variance and Duncan's multiple range test were used to analyze all other parameters (24).

**RESULTS**

A 3.7% reduction in milk yield was observed during the last week of lactation in cows dried off by abrupt milk cessation (Table 1). In
TABLE 1. Milk yield during the last week of lactation in cows dried off by abrupt milk cessation, intermittent milk cessation, or intermittent milk cessation with a simultaneous change in ration (n = 8 cows/group).

<table>
<thead>
<tr>
<th>Group</th>
<th>Yield 24 h pretreatment</th>
<th>Yield 24 h posttreatment</th>
<th>Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>SD</td>
<td>X</td>
</tr>
<tr>
<td>Abrupt</td>
<td>13.5</td>
<td>3.60</td>
<td>13.0</td>
</tr>
<tr>
<td>Intermittent</td>
<td>12.6</td>
<td>3.99</td>
<td>9.2</td>
</tr>
<tr>
<td>Intermittent plus ration change</td>
<td>12.8</td>
<td>3.52</td>
<td>4.0</td>
</tr>
</tbody>
</table>

<sup>a</sup>Significant difference between yield 24 h pretreatment and yield 24 h posttreatment (P = .005).

<sup>b</sup>Significant difference between yield 24 h pretreatment and yield 24 h posttreatment (P = .0001).

Contrast, yield was reduced 26.8% in cows milked intermittently during late lactation. The greatest reduction in milk yield (69.2%) occurred in cows intermittently milked with a simultaneous change in ration.

Numbers of somatic cells in milk prior to experimentation were similar in all treatment groups (Table 2). However, by D−3 mammary secretions from cows in group 3 had higher (P<.05) numbers of somatic cells than groups 1 or 2. Cell numbers remained elevated in group 3 until D + 2, but by D + 4 the number of somatic cells were similar in all groups and remained similar at D + 7.

The concentration of BSA in mammary secretions was approximately .2 mg/ml during

TABLE 2. Mammary secretion composition during late lactation and early involution following different methods of milk cessation (n = 8 cows/group).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Treatment group</th>
<th>Days of involution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-7</td>
<td>-3</td>
</tr>
<tr>
<td>Somatic cells (log&lt;sub&gt;10&lt;/sub&gt;)</td>
<td>1&lt;sup&gt;1&lt;/sup&gt;</td>
<td>5.57</td>
</tr>
<tr>
<td></td>
<td>2&lt;sup&gt;2&lt;/sup&gt;</td>
<td>5.27</td>
</tr>
<tr>
<td></td>
<td>3&lt;sup&gt;3&lt;/sup&gt;</td>
<td>5.20</td>
</tr>
<tr>
<td>Serum albumin, mg/ml</td>
<td>1</td>
<td>.22</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>.23</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>.25</td>
</tr>
<tr>
<td>Immunoglobulin G, mg/ml</td>
<td>1</td>
<td>.55</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>.50</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>.74</td>
</tr>
<tr>
<td>pH</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>6.8</td>
</tr>
</tbody>
</table>

<sup>a,b</sup>Means within a day of involution with different superscripts differ (P<.05).

<sup>1</sup>Abrupt milk cessation.

<sup>2</sup>Intermittent milk cessation.

<sup>3</sup>Intermittent milk cessation/ration change.

late lactation and increased markedly as involution progressed (Table 2). Significant between group differences (P<.05) were observed by 3 d prior to drying off. Serum albumin in mammary secretions from group 3 cows was higher (P<.05) than groups 1 and 2 through D + 2. However, BSA concentrations were similar for all groups at 4 and 7 d postdrying off.

Prior to experimentation, no difference in the concentration of IgG in mammary secretions between treatment groups was observed (Table 2). However, cows from group 3 had significantly higher (P<.05) IgG as early as D–3, which persisted throughout the early dry period. No differences in the concentration of IgG in mammary secretions were observed between cows in groups 1 and 2 throughout the study.

The pH of mammary secretions increased from 6.8 during late lactation to 7.4 at 7 d of involution (Table 2). Mammary secretions from group 3 cows had a higher (P<.05) pH at drying off and after 2 d of involution than cows from groups 1 and 2. The pH of mammary secretions at 4 and 7 d of involution was similar for all treatment groups.

Changes in the concentration of citrate in mammary secretions are in Table 3. The only difference between treatment groups was observed at D–3. At this time, mammary secretions from cows in group 3 had higher (P<.05) citrate than the other treatment groups. Reasons for this are not apparent. Citrate decreased slowly as involution progressed and was lowest at 7 d postdrying off.

Prior to treatment, the concentration of Lf ranged from .4 to 1 mg/ml (Table 3). Lactoferrin increased markedly as involution progressed and was higher (P<.05) in mammary secretions from cows in group 3 than groups 1 or 2 as early as 3 d prior to drying off. This difference persisted through 7 d of involution. Group 2 cows had consistently higher concentrations of Lf than cows from group 1; however, differences were not statistically significant.

Despite high concentrations of citrate in mammary secretions from group 3 cows at D–3, the citrate:Lf molar ratio was lower (P<.05) than groups 1 and 2 (Table 3). Lower citrate:Lf molar ratios were observed in group 3 cows through 4 d of involution. Mammary secretions from cows in group 2 had consistently lower citrate:Lf molar ratios than group 1 from D–3 to D + 7. However, dif-

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**TABLE 3.** Changes in the concentration of citrate, lactoferrin, and the citrate:lactoferrin molar ratio following different methods of milk cessation (n = 8 cows/group).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Treatment group</th>
<th>Days of involution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>−7</td>
</tr>
<tr>
<td>Citrate, mg/ml</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.48</td>
<td>1.53</td>
</tr>
<tr>
<td>2</td>
<td>1.56</td>
<td>1.61</td>
</tr>
<tr>
<td>3</td>
<td>1.73</td>
<td>3.11</td>
</tr>
<tr>
<td>Lactoferrin, mg/ml</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>.45</td>
<td>.48</td>
</tr>
<tr>
<td>2</td>
<td>.40</td>
<td>.69</td>
</tr>
<tr>
<td>3</td>
<td>1.05</td>
<td>3.72</td>
</tr>
<tr>
<td>Citrate:lactoferrin molar ratio, log₁₀</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3.18</td>
<td>3.20</td>
</tr>
<tr>
<td>2</td>
<td>3.20</td>
<td>3.02</td>
</tr>
<tr>
<td>3</td>
<td>3.01</td>
<td>2.64</td>
</tr>
</tbody>
</table>

a,b Means within a day of involution with different superscripts differ (P<.05).

1 Abrupt milk cessation.
2 Intermittent milk cessation.
3 Intermittent milk cessation/ration change.

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Figure 1. In vitro growth inhibition of *Escherichia coli* by mammary secretions obtained during late lactation and early involution from cows dried off by abrupt milk cessation (group 1), intermittent milk cessation (group 2), or intermittent milk cessation with a simultaneous change in ration (group 3), n = 4 cows per group.

Figure 2. In vitro growth inhibition of *Klebsiella pneumoniae* by mammary secretions obtained during late lactation and early involution from cows dried off by abrupt milk cessation (group 1), intermittent milk cessation (group 2), or intermittent milk cessation with a simultaneous change in ration (group 3), n = 4 cows per group.

DISCUSSION

A common management practice is complete cessation of milking during the 7th to 8th mo of pregnancy. High producing dairy cows are often dried off while the mammary gland is still producing substantial quantities of milk (10 to 20 kg or more). Cessation of milking results in increased internal udder pressure, which often results in leakage of milk from teats during the early dry period. This, among many other factors, has been associated with enhanced susceptibility of the mammary gland to new IMI during the early dry period (2, 4, 8, 13, 20, 23). Thus, cows producing large quantities of milk during late lactation may be more susceptible to new IMI during early involution than cows producing less milk.

Results of the present study indicate that one method of reducing milk production during late lactation is by intermittent milking. Cows milked intermittently during the last week of lactation produced about 23% less milk than cows dried off by abrupt milk cessation. Cows milked intermittently and fed hay only during
the last week of lactation produced 66% less milk than cows dried off by abrupt milk cessation and 42% less milk than cows milked intermittently. Cows in this study were producing about 13 kg of milk/d prior to experimentation. Differences in milk production between cows milked intermittently and cows milked intermittently and fed hay only during the last week of lactation suggest that abrupt alteration of nutrient intake during late lactation significantly affects milk production in a relatively short time. Lower milk yields in cows milked intermittently during late lactation compared with cows dried off by abrupt milk cessation indicate that the omission of the milking process was related to decreased production. Previous work (1, 17) has shown that periodic omission of milking significantly affects milk yield, which could be related to lack of hormonal stimuli associated with the milk ejection process or with lack of hormonal stimuli independent of milk ejection.

Methods of intermittent milking have varied among the few studies that have been conducted. Intermittent milking can involve omission of one milking per day for several days, increasing the interval between milkings, or leaving the udder incompletely milked (11, 26, 27). Early studies by Wayne et al. (27) and Wayne and Macy (26) indicated that abrupt cessation of milking was the preferred method to dry off cows. However, their procedure of intermittent milking consisted of milking two quarters of a udder half once per day for as long as possible after drying off, while the other two quarters of the same cow were dried off by abrupt milk cessation. Thus, hormones associated with the milking stimulus, especially oxytocin, most likely affected all quarters of the cow and confounded their data.

In the 1950's, Oliver et al. (11) conducted a study to determine if different methods of milk cessation influenced the rate of new IMI during the dry period. Cows producing about 3.2 kg/d were milked intermittently by once-a-day milking for 28 d, then milked again 3, 7, and 14 d later. However, many cows in this study were dry before the end of the once-a-day milking period. A second method involved once-a-day milking for 14 d followed by stripping on the 3rd and 7th succeeding days. Intermittent milking was compared with abrupt cessation of milking. Quarters of cows that were uninfected at drying off had a significantly higher incidence of new IMI following abrupt milk cessation than following intermittent milk cessation. They also showed that the method of drying off had no effect on IMI that were already established in quarters going dry and that different methods of milk cessation did not affect milk yield in the next lactation (11).

A subsequent study by Oliver et al. (12) evaluated different methods of milk cessation in cows with daily milk yields of 3.2 to 10 kg at the time of drying off. Cows producing <3.2 kg daily were dried off by intermittent milk cessation, while cows producing >3.2 kg of milk daily were dried off by abrupt milk cessation. They found that the rate of new IMI during the dry period was highest in cows producing the most milk at the time of drying off. The practical implication of this study was the need to reduce milk yield during late lactation.

Early studies (11, 12, 26, 27) evaluating the effects of different methods of milk cessation on rates of IMI during the dry period are not necessarily applicable to today's dairy cows, which produce significantly greater quantities of milk during late lactation than cows in previous studies. Furthermore, intermittent milking for extended periods (14 d or longer) seems economically counterproductive.

More recently, Natzke et al. (6) determined effects of drying off practices on rates of new IMI during the dry period. Cows not infused with antibiotics at drying off and milked once daily for 3 d prior to drying off had fewer new IMI at parturition than cows dried off by abrupt milk cessation. Quarters of cows dried off by abrupt milk cessation and infused with dry cow antibiotics had a slightly lower cure rate and a higher number of new infections than intermittently milked cows. However, Natzke et al. (6) indicated that the use of antibiotic dry cow therapy overshadowed any desirable effects associated with the intermittent milking procedure. It should be noted that about 42% of cows in their study were producing <4 kg of milk at drying off, 44% between 5 and 8 kg, and only 15% producing >9 kg of milk at drying off.

Results of previous reports (6, 11, 12) suggest that methods of decreasing milk production during late lactation can have a marked impact on the rate of new IMI during the dry
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In this regard, mammary secretions from cows milked intermittently and fed hay only during late lactation (group 3) produced the least amount of milk that contained the highest concentrations of somatic cells, Lf, and IgG. Significant increases were first observed 3 d prior to drying off, which persisted throughout most of the study. Furthermore, mammary secretions from cows in group 3 also had a higher concentration of serum albumin, a higher pH, and a lower citrate:Lf molar ratio during the first 2 to 4 d of the dry period, suggesting that mammary glands of cows milked intermittently and fed hay only during late lactation involuted more rapidly (2, 16, 20). In spite of a significant reduction in milk yield for cows milked intermittently during late lactation (group 2), no differences in mammary secretion composition were detected when compared with mammary secretions from cows dried off by abrupt milk cessation (group 1). Cows in group 2 produced about 9 kg of milk/d during the last week of lactation. Thus, increased concentrations of natural protective factors in mammary secretions do not appear to occur until milk volume is reduced below 9 kg.

Inhibition of *E. coli* and *K. pneumoniae* growth was greatest in mammary secretions from cows milked intermittently with a simultaneous change in ration during the last week of lactation. Increased bacterial growth inhibition corresponded with elevated concentrations of Lf and IgG and a lower citrate:Lf molar ratio. In general, little to no growth inhibition of coliform mastitis pathogens was observed at 7 d prior to drying off. However, mammary secretions from cows in group 3 at 3 d prior to drying off were more inhibitory to growth of *E. coli* and *K. pneumoniae* than secretions from cows in groups 1 and 2. Increased inhibition by mammary secretions from cows in group 3 was observed throughout the 1st wk of involution. Few differences in bacterial growth inhibition were detected between mammary secretions from cows milked intermittently during the last week of lactation and cows dried off by abrupt milk cessation throughout the experimental period. These data agree with previous studies (3, 10, 20) and suggest that elevated concentrations of natural protective factors at drying off and during early involution may aid in the protection of the mammary gland at a time when the udder is highly susceptible to new IMI.

Several recent reports have shown that bovine mammary involution can be accelerated, resulting in elevated concentrations of natural protective factors in mammary secretions. Intramammary infusion of colchicine (15, 16), endotoxin (16), phytohemagglutinin, or concanavalin A (2) at or near drying off caused significant reductions in milk yield and significant alterations in secretion composition similar to results of the present investigation. However, intermittent milking of dairy cows with a simultaneous change in ration during late lactation seems to be a more practical means of reducing milk yield at drying off and increasing natural protective properties of mammary secretions during the early dry period.

Methods of decreasing milk production during late lactation may be particularly relevant in herds experiencing environmental mastitis. Studies (14, 21, 22) have shown that the rate of new coliform IMI during the early dry period can be high. Elevated concentrations of natural protective factors, in particular Lf, may be effective in preventing new IMI by coliform mastitis pathogens during early involution. Previous studies suggested that Lf, because of its iron binding affinity, may be a major factor in the nonspecific defense of the involuting bovine mammary gland (13, 20, 23).

Methods of lowering milk production at drying off may also increase efficacy of dry cow antibiotics. Higher concentrations of antibiotics may be present in mammary tissue and mammary secretions of cows producing minimal quantities of milk at drying off. Furthermore, the chances of milk leaking from udders of cows during early involution would be reduced, thus reducing the possibility of antibiotics leaking out of cows' mammary glands as well. Also, enhanced concentrations
of natural protective factors in addition to dry cow antibiotics may be more effective in preventing new IMI during the dry period and more effective against a broader spectrum of mastitis pathogens. Further studies are needed to determine if different methods of milk cessation in high producing dairy cows influences the incidence of IMI during the non-lactating period.

ACKNOWLEDGMENTS

The authors are grateful to R. E. Scannell and M. E. Fydenkevez for technical assistance and to G. Gritzner for clerical assistance.

REFERENCES

12 Oliver, J., F. H. Dodd, and F. K. Neave. 1956. Udder infections in the dry period. IV. The relationship between the new infection rate in the early dry period and the daily milk yield at drying-off when lactation was ended by either intermittent or abrupt cessation of milking. J. Dairy Res. 23:204.