DECIDING TO DRY-OFF: DOES LEVEL OF PRODUCTION MATTER?

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Introduction

The dry period is a crucial phase in the lactation cycle of a dairy cow. Dairy managers aim to dry off pregnant cows to achieve a dry period of appropriate length to maximise productivity in the next lactation (5,6,7,17,19). The herd average dry period length is correlated with herd average milk production (12). A dry period of 60 days is considered ideal. As the herd average days dry deviates from 60 days, average milk production of the herd decreases. However, as the genetic potential for milk production continues to increase, it becomes a management challenge to stop milk production in high producing individuals in order to achieve the 60 day goal.

The dry period is an anatomically and physiologically challenging time for the cow and her udder (2,20,24,25,). It is a time of nutritional, metabolic and mammary change that will profoundly impact health and productivity in the next lactation. The fetus completes almost two-thirds of its growth during the last two months of gestation. This fetal growth takes priority over the cow's own needs for body tissue maintenance. The rumen papilla and microflora must adapt to the change from an energy dense lactating ration to one that meets basic maintenance requirements, and then prepare again during the transition period to adjust back to the lactating ration. The udder undergoes drastic gross and cellular changes as well. Immediately following milk cessation, there is marked engorgement of the cisternal spaces, ducts and alveoli of the gland. The composition of the milk being secreted is altered, and the secretory tissue of the gland begins to regress until involution is complete (25). This is a fundamental process as the majority of mammary tissue growth and development occurs during involution. After the epithelial cells regress and their secretory activity decreases, there is another period of transition as calving approaches. This transition is characterized by rapid differentiation of secretory tissue, intense growth and accumulation of fat, protein and colostrum. The udder is highly susceptible to new infections during both the transition from lactation to involution and also from involution to colostrogenesis (25). It is indeed surprising that very little has been reported about the impact that various approaches to drying off have on udder health.

The importance of a dry period with respect to udder health management programs has been well documented (2,5,9,19,23,24,29). The epidemiology of new intramammary infections (IMI) during this time is well recognized, as is the importance of infections that persist into the next lactation (5,17). A major goal of the dry period is to have as few quarters infected at the next calving as possible (12). This goal can be partially achieved by administering dry cow antibiotic therapy at the end of lactation (5). Some of the research directed towards improving udder health during the dry period has focussed on methods to enhance the efficacy of

antibiotic treatment (10,11), protecting teat ends from bacterial contamination (13,30), manipulation of udder involution (26), and vaccination with gram negative core antigens (14). However, all of these methods are not implemented until after the last milking. The effect of management factors that take place within the two weeks prior to scheduled drying off are precluded in any definition in which the dry period begins only when milking stops.

In 1950, when the early dry period was first identified as a significant period of risk for new IMI (19), the investigators differentiated a "dry period" from the "true dry period". The "dry period" was defined as the 14 days before last milking until the 14 days after calving, whereas the "true dry period" was only the time during which the cow was not being milked. Having made such a distinction, specific attention could be focused on determining if the method of drying off had an influence on the development of IMI during the dry period (18,27).

The difference between abrupt or intermittent cessation of milking, and the influence of a change in ration during this time period have been investigated (27). Based on data from two research herds, it was concluded that the method of milk cessation could affect the rate of IMI during the dry period, but that additional studies using other herds and different patterns of infection would be required. In spite of this work, other than the use of blanket dry cow antibiotic therapy, there is no clear recommendation available on the best method to dry off cows. Specific guidelines to manage cows from two weeks before until two weeks after drying off are noticeably absent from scientific and lay literature. The National Mastitis Council (NMC) does make a specific recommendation for drying off. The NMC recommends: "High producing cows should be taken off concentrate feeding two weeks before anticipated dry off. A change in environment can also help reduce production. When all quarters of cows are dry treated after the last milking, abrupt cessation of milking is recommended..."(16). However, the source data for this recommendation is not presented. Therefore, the objective of this paper is to review the published literature pertaining to drying off, and to identify important gaps in our knowledge. In particular, the importance of the level of milk production at drying off and its relationship to the development of new IMI's will be considered. The overall aim is to identify specific management practices that can be manipulated to reduce the risk of new intramammary infections at the time of drying off and in the early dry period.

Method of Milk Cessation

Different methods to stop milk production at the end of lactation have been studied. The two most common methods are to abruptly stop milking and to intermittently milk the cow on a particular schedule leading up to the final milking. In both cases, herd specific drying off practices, including dry cow antibiotic therapy, are administered immediately after the last milking. It is important to realize that the definition of "intermittent" varies across studies, and is not synonymous with one approach. Intermittent may refer to once a day milking every other day for the week prior to drying off, or it may mean milking once a day during the week prior, with the cow not being milked the day before drying off. Abrupt cessation of milking implies that milking proceeds as usual, irrespective of scheduled drying off, and simply stops when the cow is to go dry. Crucial to the debate over the benefit of either method, is to resolve the importance of the level of milk production at dry off. Although specific reasons for the

increased risk of IMI during the early period are unclear (5), increased intramammary pressure in high producing cows is believed to be one important factor (5,25).

Intermittent cessation of milking has been shown to decrease milk production by 22% to 47% of total milk yield during the last week of lactation (27). Prior to abrupt cessation of milking, total milk yield during the last week of late lactation for cows not on BST, normally decreases between 3.7% and 10.4% (27). Regardless of the management approach, there is still great variation in the actual milk yield on the day of dry off. It has been suggested that increased intramammary pressure, resulting from a full gland that is not being evacuated, may cause leakage from quarters, thus allowing bacteria to penetrate the teat canal and colonize in the gland. Also, the increased volume of milk contains lower concentrations of natural protective factors such as lactoferrin, immunoglobulins and phagocytic cells (1,28). Decreasing the level of production at drying off could directly increase the resistance of the udder in the early dry period by minimizing these effects.

In a two-year study involving 188 cow-dry periods, the rate of new IMI in cows dried off by abrupt cessation was 45.1% (21). The rate of new IMI in cows dried off by intermittent cessation was 43.3%. The rates of new IMI in quarters were 24.6% and 18.4% for abrupt versus intermittent cessation, respectively (21). Intermittent cessation meant the cow was milked out once per day for at least 14 days, and then stripped out on the succeeding third and seventh day (21). It is important to note that the milk production at dry off in these cows (7 lbs/day) is well below the current industry average. However, when only cows with all 4 quarters uninfected at drying off were examined, there were significantly more new quarter infections in cows abruptly dried off than those with intermittent cessation of milking (19.7% versus 11.6%). This was one of the first indications that the method of drying off impacted new infection rates. Interestingly, the decline in milk yield seen during the last week of lactation was similar in the two groups (9.2% for abrupt and 10.9% for intermittent). In addition, the method of ending lactation did not affect milk yield in the subsequent lactation.

In 1990, Oliver, Shull and Dowlen reported the influence of milk cessation on mastitis in high producing Jersey cows (27). In their study, 155 cows were randomly assigned to be dried off by abrupt cessation versus intermittent milking once a day for seven days. In addition, within these two groups, each cow was randomly assigned to receive either the normal lactating cow ration or hay only. There was a dramatic effect on reduction in milk yield during the last week, with the greatest reduction (60-66%) observed in cows milked intermittently and offered only hay. The rate of IMI during the dry period was reduced 32% in antibiotic treated quarters of cows dried off by intermittent milk cessation. By comparison, the rate of IMI was reduced 50% when cows were milked intermittently with a simultaneous ration change. Overall, the method of milk cessation had an affect on the incidence of mastitis caused by both major and minor pathogens. It was concluded that intermittent milking followed by dry cow antibiotic therapy might be the best approach to dry off cows.

Although this evidence supports the use of intermittent milking to end lactation, there is no single regimen that has been recommended to dairy producers. Also, there is no documentation of the protocols of intermittent milk cessation being used by producers employing this method.

It is disappointing that large-scale surveys of the industry have failed to capture these data. In 1996, the USDA released the National Animal Health Monitoring System (NAHMS) dairy survey (15). This was a major effort to document common management practices on dairy farms across the United States. However, as comprehensive as this initiative was, it did not describe how cows are commonly dried off at the end of lactation.

Association Between Milk Yield at Drying Off and Mastitis

The method used to end lactation has been driven by the underlying principle that less milk in the udder will result in fewer infections. This has been demonstrated when milk production has been reduced through intermittent milking (27). It remains to be determined if there is an optimal level of production at which cows should be dried off.

One of the preliminary studies to investigate this question was carried out in 1956 (22), subsequent to the first report that there was a difference in new IMI between different methods of drying off. Over a four year period, 113 cow-dry periods were examined in a herd with approximately 20% of cows producing 20 lbs of milk around the time of drying off. There was a significant difference in the incidence of mastitis when cows were stratified based on production, while controlling for age. When production at drying off was less than 7 pounds of milk, 41.7% of cows (18.4% of quarters) became infected during the dry period. By comparison, 71.4% of cows (43.4% of quarters) producing greater than 21 pounds of milk developed new infections. There was no association between yield at drying off and milk production in the subsequent lactation (21). Analysis of the data stratified on the basis of production allowed the investigators to conclude that once milk production has decreased to 10 lbs, it appears safe to end milking abruptly. However, it was suggested that it might be safe to abruptly end lactation at higher levels with proper teat end sanitation.

An investigation of the effect of drying off practices on mastitis infection was conducted in the early 1970's in New York dairy herds (18). Comment was made about the importance of the level of production at drying off, while the study also confirmed the importance of dry period length and dry cow antibiotic therapy. The new infection rate ranged from 8-18% of quarters. The level of milk production at drying off had no significant effect on the rate of new IMI. However, cows with lower production at drying off were more likely to be found infected immediately before drying off. Intermittent cessation of milking was concluded to be the better technique to end lactation when dry cow antibiotic therapy was not used. The effect of method of drying off on new infection rate was decreased when dry cow antibiotic therapy was used. It was suggested that the number one management factor that can be easily manipulated to alter the number of quarters becoming infected during the dry period is the use of dry cow antibiotic therapy. This may still be the best advice available to producers today. That is, as the importance of various management factors continues to be investigated and manipulated to improve the success of the dry period, the benefit of practices such as dry cow antibiotic therapy and post milking teat disinfection cannot be neglected.

There continue to be conflicting reports on the overall effect of milk yield prior to drying off on the risk of infection. One specific level of production has not been cited as optimal.

Irrespective of a definitive production level, it appears clear that the benefit of intermittent milking, and the associated decline in production, has a positive effect on decreasing the rate of new IMI during the dry period.

Use of DHI Records to Investigate the Effect of Milk Production at Dry Off

It is becoming increasingly difficult to conduct the intensive studies required to answer questions such as "does level of production at drying off matter?" To be scientifically valid and meaningful to the industry, such studies need to involve a large number of cows, under various herd management practices, in different geographical regions, over a long time period of time. The cost of mounting such endeavours is often prohibitive. In addition, the resources needed to accomplish the objectives are hard to maintain for extended periods of time. Therefore, different ways to answer the same questions need to be found. One such method could involve making use of the DHI records that are collected each month on millions of dairy cows across North America.

Recently, Ontario DHI records were examined to determine if an association exists between the level of production at dry off and change in udder health status over the dry period. Since DHI records contain production data for an entire lactation, the length of the dry period in days, days in milk and milk production at dry off can be calculated. In addition, cow level raw SCC, linear score, age and parity are readily available. On the other hand, there are concerns with the accuracy of the date of dry off which is used to calculate the dry period length. Milk production on the actual day of dry off has to be projected using 305 mature equivalent milk, assuming no change in milking frequency or feeding program prior to dry off. Bacteriological culture results from milk samples collected at dry off and subsequent calving are not commonly available. Based on more than 30,000 cow lactations completed between January 1998 and December 1999, the median days dry for Ontario cows was 59 days (Figure 1). This is slightly less than the 60 or more days often reported from producer surveys. For example, in the NAHMS Dairy Survey (15), 53.2% of farms reported a dry period of 60-69 days in length, compared to only 28% reporting a dry period comprised of anything less than 60 days. There is a concern that these survey data are not an accurate reflection of the dry period, but rather an indication that producers know what an optimal dry period length should be.

Milk yield on the day of drying off was projected using milk yield on last DHI test day and extrapolating to the dry date using a standard slope parameter. This assumes that cows were not subjected to a major management change such as intermittent milking or a ration change during the days prior to dry off. The distribution of milk production at drying off in presented in Figure 2, with a mean of 16.6 Kg (36.5 lbs.). The association between milk production at drying off and udder health status was investigated using SCC data. A new IMI was defined as a change in linear score from less than 4.0 at last test prior to drying off to a linear score greater than 4.0 at first test in the next lactation. This change in linear score is used in many herd management software programs to identify newly infected cows, and has been recommended as a reasonable threshold to detect subclinical mastitis (4). Twenty-six percent of cows producing greater than 21 Kg of milk at dry off developed new IMI, compared to only 16% of cows producing less than 13 Kg of milk (Figure 3). While this was a statistically

significant difference ($p < 0.05$), it is clear that the new IMI could have developed either just prior to dry off, or just after freshening, and not necessarily during the dry period.

To be more precise in our ability to answer the question of what influence milk production has, an extensive study in herds with computerized daily milk weights, involving strategic quarter milk sampling would be required. Ideally, assessment of other important factors such as udder involution, closure of the teat streak canal and management practices of the herds would be collected. Such a study has recently been initiated, and more than 250 cows are currently enrolled from herds in Ontario, Kansas, New York and Iowa.

Intervention Strategies

It has been shown that decreasing milk production is an important management strategy associated with drying off. It is plausible that other commonly used strategies could be strategically targeted to achieve this goal. For example, the NAHMS survey of management practices indicates that 26.6% of producers vaccinated dairy cows for mastitis caused by *Escherichia coli*. For all of the commercially available products containing a bacterin–toxoid of J5 mutant E. coli, the product labels indicate they should be administered at dry off. However, there could be a more appropriate time to give these vaccines, knowing that it is desirable to decrease milk production in preparation for dry off. It has been reported that cows vaccinated with the *E. coli* vaccine experience a significant short-term decrease in milk production (14). In a randomized controlled clinical trial, vaccinated cows produced approximately 7% less milk than unvaccinated controls in subsequent milkings. Therefore, altering the time in which this vaccine is given to dairy cows relative to drying off could augment the decrease in milk production that is important prior to drying off.

It is important to realise that although a management or therapeutic strategy may have benefits on its own, using it in conjunction with dry cow antibiotic therapy at the time of drying off may produce serious adverse effects. For example, recombinant bovine interleukin-2 increases the number of somatic cells and activates phagocytosis of polymorphonuclear leukocytes. During one experiment, intramammary infusion of this cytokine resulted in a 40% cure rate of experimentally induced *Staphylococcus aureus* mastitis (3), and showed promise to significantly increase cure rates when used in conjunction with dry cow antibiotic therapy. In a field trial (8) to evaluate its concurrent use, therapeutic efficacy against *S. aureus* was increased from 33% with dry cow therapy alone, to 54% with dry cow therapy and this cytokine given at dry off. However, there was an observed association between the administration of Interleukin-2 and abortions during the early dry period. These results quickly discouraged the adoption of this protocol (8).

Summary

The dry period is a crucial stage of the lactation cycle with respect to udder health. Cows are at increased risk of developing IMI during the early and late dry period. Management practices incorporated in the process of drying off are important determinants of new IMI during the dry period. Intramammary administration of dry cow antibiotic therapy at the end of

lactation is important to eliminate existing infections, and prevent new infections from occurring. However, other than the recommendation of blanket dry cow therapy, guidelines for producers on how to manage cows from 2 weeks prior until 2 weeks following drying off are not well established. The risk of new IMI might be reduced if milk production decreased prior to dry off, the udder involuted rapidly, and the teat canal closed in a timely manner.

Sparse attention has been paid over the years to determine which method, either abrupt or intermittent cessation of milking, is best to end lactation. Although contradictions exist in the literature, it has been demonstrated that the greatest reduction in milk yield in the last week of lactation is achieved through intermittent milking. This reduction can be facilitated by a ration change to hay only and short periods of water restriction. It has been shown that cows milked intermittently produce less milk and have fewer new intramammary infections in the dry period caused by either major or minor bacterial pathogens. Furthermore, cows producing less milk have higher concentrations of inhibitory factors and cells in their udder.

The optimal level of milk production at dry off to realise a decreased risk of new IMI has not been established. Significant reductions in new IMI rates have been achieved when production dropped to less than 10 pounds per day. This may not fit with the phenotypic expression of the genetic potential of the modern Holstein cow. Nonetheless, it may be important to move towards a recommended level of production prior to dry off. In order to make such recommendations, large scale studies representative of the breadth of the dairy industry are needed. While this presents many challenges, there are opportunities to use existing production, dry period and udder health data routinely collected through DHIA organizations to tackle this issue.

As we work towards a better understanding of the importance of milk production at dry off, it it imperative that we continue to promote the importance of traditional practices such as dry cow antibiotic therapy and proper teat disinfection. These may yet prove to be the most important factors that mitigate the risk of new IMI during the dry period. Furthermore, the ability to implement various dry off procedures in a given herd will vary depending on the facilities, available labour and management structure of the enterprise.

Figure 1. Distribution of Dry Period Length in Days from Ontario DHI Data

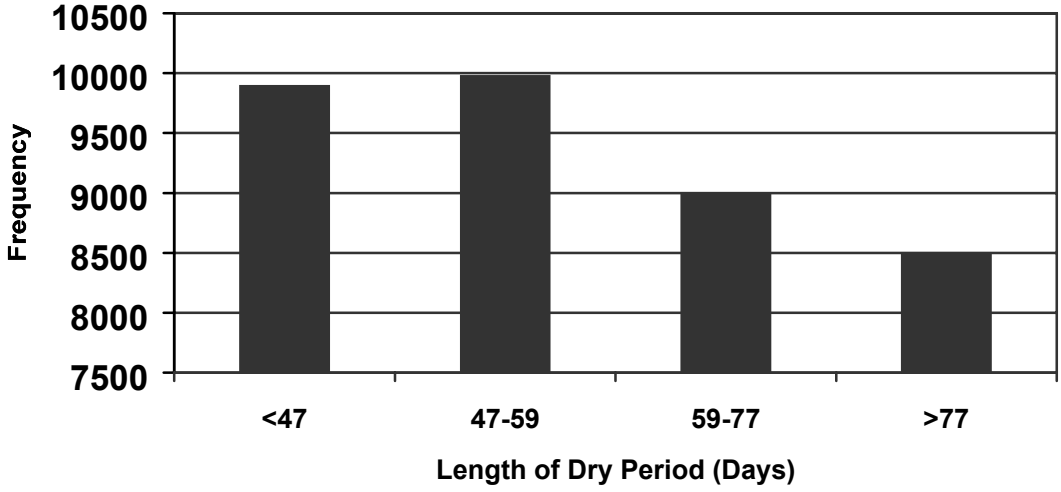


Figure 2. Frequency Distribution of Milk Yield at Dry Off

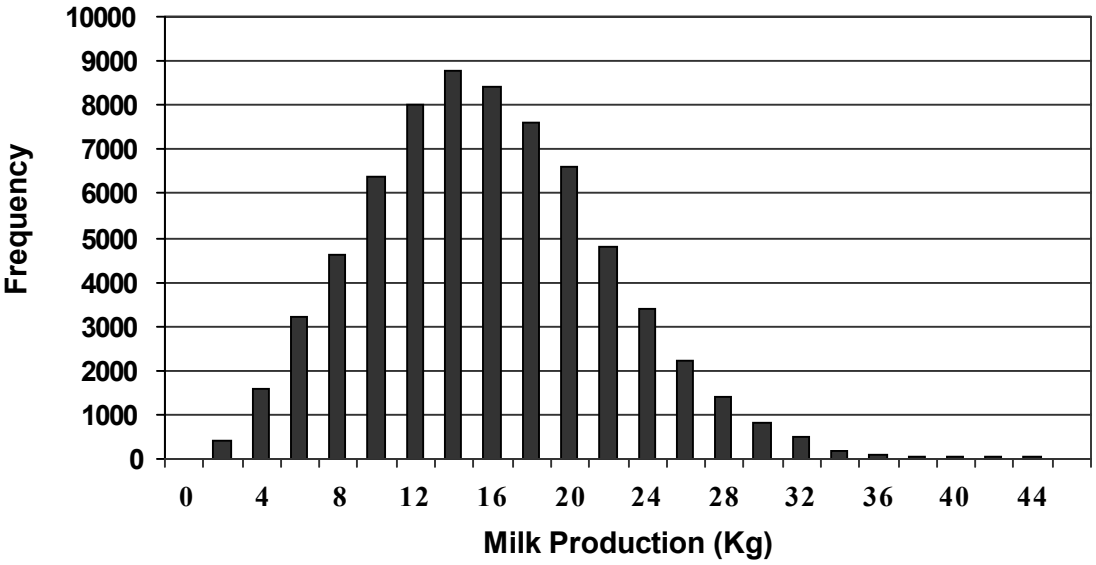
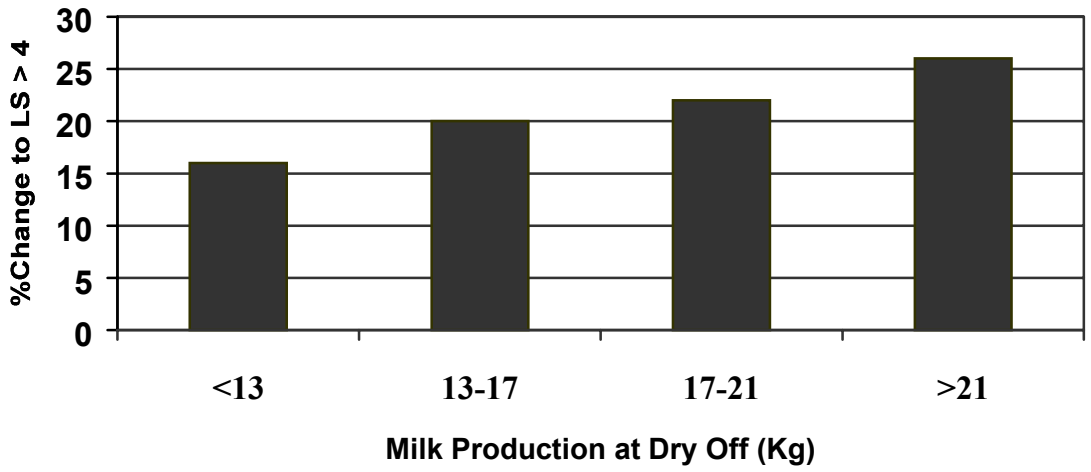


Figure 3. Percent of cows with Change in LS by Milk production at Dry off



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