Managing Mastitis *through* Proper Dry-Off Procedures

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Mastitis, also known as intramammary infection (IMI), occurs when bacteria enter the teat orifice (opening), multiply within the mammary gland, and elicit an inflammatory response. This inflammation results in an increase in the somatic cell count (SCC), which, in combination with secretory tissue damage caused by IMI, leads to decreased milk quality and yield. In addition, mastitis in its clinical form may adversely affect animal health and well-being.

The cow's udder is highly susceptible to new IMI during the beginning and the end of the nonlactating (dry) period. ***An understanding of the physiology of the dry period as well as the anatomy of the teat end is instrumental in maximizing the benefits of properly drying off mammary quarters to both cure existing IMI and to prevent new infections.***

The Dry Period

After drying off, the mammary gland progresses through three distinct stages: 1) active involution; 2) steady state involution; and 3) colostrum formation or "colostrogenesis."

During ***active involution***, which lasts for three to four weeks, mammary quarters are highly susceptible to new IMI from environmental mastitis-causing bacteria such as *E. coli* and *Strep. uberis*. This is due to several factors: 1) The flushing of bacteria colonizing the teat canal is terminated because cows are not being milked two to three times a day; 2) bacteria accumulate on the skin because udder sanitization and teat dipping have been discontinued, thereby increasing the chances of infection; 3) due to milk accumulation and subsequent dilation and shortening of the teat duct, there is milk leakage and loss of keratin, providing an open pathway for bacterial invasion; and lastly, 4) leukocytes are more active in removing milk components such as casein and fat than microorganisms, making them less efficient in preventing new IMI.

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During ***steady state involution***, which lasts from one to two weeks, the susceptibility to new IMI is very low. This is due to high levels of antibacterial factors such as antibodies, which aid in leukocyte elimination of bacteria, and lactoferrin, which sequesters milk iron from bacteria that require it for survival. More importantly, there is a reduced rate of bacterial penetration through the teat canal because of the development of a keratin plug (discussed in the following section).

Colostrogenesis, the final phase of the dry period, lasts from one to three weeks. Susceptibility to new IMI is increased just prior to calving. This is due to colostrum accumulation and subsequent dilation and shortening of teat duct, leading to fluid leakage and loss of keratin, providing an open pathway for bacterial invasion. Additionally, there are reduced leukocyte numbers and loss of their ability to engulf microorganisms. Moreover, mastitis microorganisms utilize milk components for their own growth and multiplication. Finally, there is absence of residual antimicrobial activity of the dry cow therapy that was infused at time of drying off.

Teat End Defenses

The teat has two primary defense mechanisms against mastitis-causing bacteria (Figure 1). The first is keratin, which blocks the teat canal. This substance serves as a physical barrier against bacteria and also contains antibacterial proteins and fats that inhibit bacterial growth. The second defense is a sphincter muscle, which surrounds the teat canal and compresses the keratin, remaining contracted to help prevent bacterial penetration into the teat orifice.

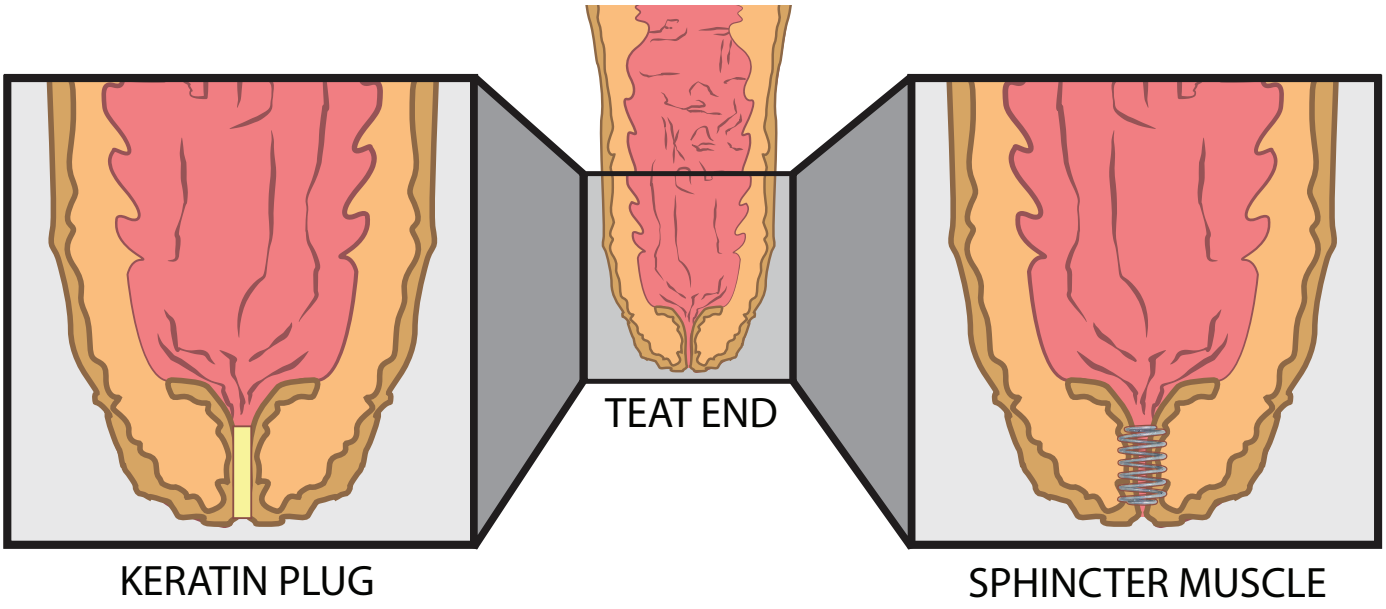

Figure 1. The cow's teat end provides protection against mastitis-causing bacteria in the form of 1) a keratin plug and 2) a sphincter muscle.

Protection of these teat end defenses at the time of drying off is critical to the outcome of administering antibiotic dry cow therapy and/or teat sealants. When these treatments are applied through the teat end, the natural tissue architecture (keratin and sphincter muscle) should be protected as much as possible to maximize treatment efficacy. This means that the teat orifice should be sanitized and the partial insertion method of introducing only the distal end (tip) of the syringe cannula should be followed.

The recommended method for administering dry cow therapy or internal teat sealants is to use the partial insertion technique (Figure 2a). By inserting only the tip of the cannula (1/8–1/4 inch), the keratin and sphincter muscle will remain in their natural positions, which avoids dilating the canal. Moreover, using partial insertion will minimize any contaminating bacteria at the teat orifice from being carried upwards into the gland and causing a new infection.

When syringe cannulas are fully inserted into the teat canal (Figure 2b), it stretches the sphincter muscle, dilates the teat canal up to eight times its normal diameter, and removes keratin by pushing it upward into the teat cistern, leaving an open pathway for bacteria. Also, by inserting the cannula fully into the canal, any contaminating bacteria at the teat orifice can be carried upwards into the gland. If these are environmental organisms such as *E. coli*, they are likely drug resistant, and a new infection will be initiated.

For properly infusing any treatment into a mammary quarter, it is important to 1) sanitize the teat orifice while wearing gloves (minimizes bacterial transfer); 2) infuse using the partial insertion technique; and after infusion 3) immerse teats in a germicidal teat dip to destroy any contaminating bacteria.

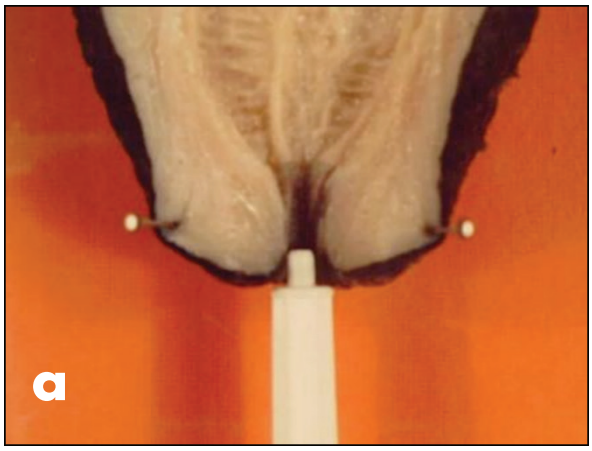

Figure 2a. Partial insertion maintains the normal protective mechanisms of the teat end.

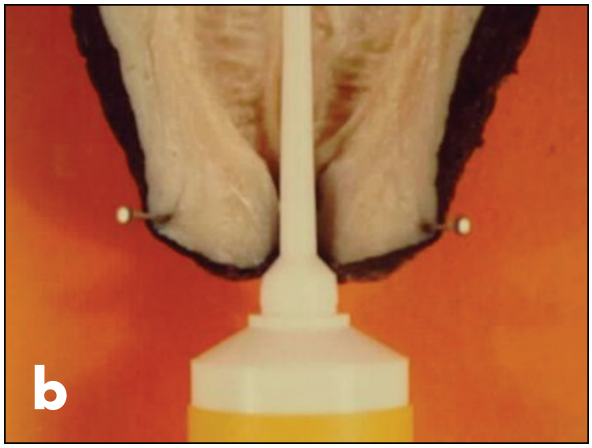

Figure 2b. Full insertion compromises teat canal keratin and sphincter muscle function.

Minimizing Stress and Environmental Exposure

For very high producers, it may be necessary to reduce feed intake over last two weeks of lactation to reduce yield by the time of drying off. This includes feeding a high fiber diet, reducing or eliminating grain, and switching from a high to a low quality forage source. Reducing water intake to lower yield is questionable as it is the most crucial nutrient and promotes animal health, especially during the warm season.

After drying-off, cows should be switched to a balanced gestation diet. A body condition score of about 3.5 or less is recommended at dry-off. Over the nonlactating period, animals should be provided with fresh, clean pasture, or if housed, provided adequate ventilation to decrease moisture, which reduces bacterial growth and minimizes mastitis. During periods of heat stress, some form of relief must be provided.

Methods of Drying Off

Either of two methods may be used to dry cows off: 1) abrupt cessation of milking and 2) intermittent milking. With abrupt cessation of milking, cows are milked until the dry off date, and then milking is immediately terminated. Cows are infused with dry cow therapy and/or teat sealant, and placed in a far-off pasture or a housing area. With intermittent milking, cows are milked until about one to two weeks prior to the dry-off date. Then, for the last one to two weeks of lactation, concentrates are eliminated, and cows are fed hay only. Cows are milked intermittently (e.g., once a day for one to two weeks), and then infused with dry cow therapy and/or teat sealant. Research has shown that the practice of intermittent milking accelerates mammary regression, thereby bringing the udder to the steady state involution phase faster, promoting development of antibacterial factors, and decreasing the new infection rate.

Dry Cow Therapy, Teat Sealant, or Both?

Without culturing milk samples or conducting somatic cell counts, the infection or SCC status of individual mammary quarters at drying off remains unknown. However, prevalence of mastitis among quarters at this time generally may range between 10–30%; likewise, new infections in quarters not treated at dry-off with antibiotics or sealants may also range between 10–30%. Thus, it is recommended that dry cow therapy, internal teat sealant, or both be used at drying off to cure existing IMI and prevent new infections, so that cows may freshen free of mastitis with low SCC.

Note: ***External*** teat sealants are also available, which are applied to the outside surfaces of teats (Figure 3a). At dry-off, teats are immersed in an external sealant that provides a physical barrier for the teat orifice against bacterial penetration during critical times in the dry period, e.g., early dry-off and seven to ten days pre-calving. Products last for about six days and may need reapplication. Combined with antibiotic infusion, external sealants may provide additional protection compared to dry cow therapy alone. One field trial showed a 47% reduction in new infections among cows that received an external teat sealant alone. Whether such sealants can be recommended as a substitute for dry cow therapy at this time is unknown. The majority of teat sealant research has emphasized use of ***internal*** sealants (Figure 3b), which will be the focus of the rest of this section, whether used alone or in combination with dry cow antibiotic therapy.

It must be reiterated that the goal of dry cow therapy is to *cure* existing infections present at drying off and to *prevent* new infections that occur in the early dry period. But, effective action of the antibiotic is usually gone within four weeks. Internal teat sealants are inert products containing bismuth and mineral or paraffin oil, which are infused at dry-off and removed at first milking. They have no antimicrobial components, but serve as an important physical barrier to bacterial penetration over a normal 60-day dry period, so they are effective in *preventing* new infections between dry-off and calving. The question becomes: Should quarters be treated with dry cow therapy, teat sealant, or both?

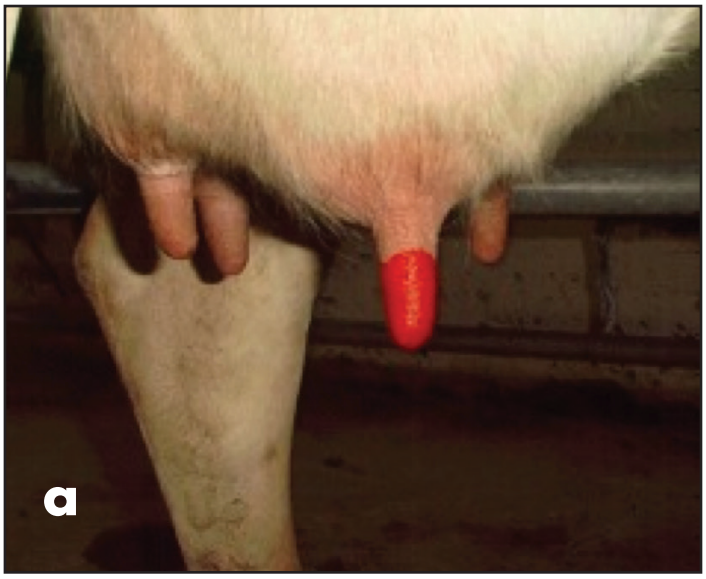

Figure 3a. An *external* teat sealant, which provides a physical barrier on the outside of the teat.

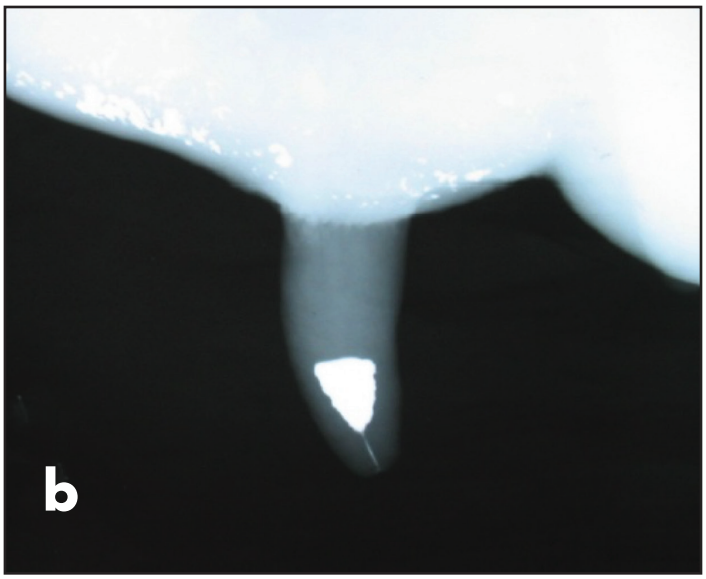

Figure 3b. An *internal* teat sealant, which provides a physical barrier on the inside of the teat.

By far, most research on this subject over the past 50 years has focused on dry cow therapy and has emphasized treating of all quarters of all cows at dry-off, also known as "blanket" dry cow therapy. This protocol originated in the 1950s. Since that time, university research has demonstrated that blanket dry cow therapy is 70–90% effective in curing existing cases of mastitis and 50–80% effective in preventing new infections.

Because of the success of dry cow therapy in curing IMI, the question arises: "Can cure rates be improved by treating each quarter twice (two tubes/quarter) or at dry-off and at some later time(s) during the dry period?" Such multiple infusions have not been demonstrated to be beneficial. Moreover, subsequent treatments after dry-off may pose additional risks by introducing bacteria into the gland via the syringe cannula as well as increasing risk of antibiotic residues in bulk tank milk after freshening. Thus, most researchers recommend a single infusion of nonlactating cow antibiotic per quarter, which will typically persist in the gland for two to four weeks.

More recently, *selective* antibiotic dry cow therapy has become popular, which is based on selecting only the infected or potentially infected quarters (or cows) to treat. This has been promoted to reduce expense, drug use, and the development of antibiotic-resistant bacterial strains. The "selection" is based on culture of milk samples and/or SCC. For the SCC, a reasonable threshold above which to treat is 200,000/ml, and for cows/quarters assumed to be uninfected (e.g., < 200,000/ml), teat sealants could be used to prevent new infections.

Recent studies demonstrated that in low SCC cows (< 200,000/ml at time of dry-off), selectively treating only those cows diagnosed with IMI (positive bacterial culture) with both dry cow therapy and teat seal was as good as blanket therapy with both products. Other studies have shown that use of teat seal alone in low SCC cows (< 200,000/ml at time of dry-off) was as good as dry cow therapy against most bacterial infections, but actually better in preventing coliform infections at time of calving. A recent summary of 12 trials evaluating teat seals and dry cow therapy showed that use of both products in combination or teat seal alone was equally effective in reducing the number of new IMI as well as clinical mastitis cases at calving. However, the addition of the dry cow therapy lowered SCC at calving, suggesting that the antibiotic component was effective in curing existing infections at the time of drying off, hence, lowering SCC.

Additional Herd Health Issues to Consider

Over the dry period, cows housed in a confined space should be cooled during the warm season with cool drinking water, sprinklers, and fans; pastured animals should be provided with sufficient shade and cool drinking water. This will enhance cow comfort, promote dry matter intake, maintain immune function, and help to reduce incidence of mastitis. Likewise, cows should have access to clean bedding and/or pasture to minimize the bacterial load on the teat end and reduce the new udder infection rate. A balanced gestational diet should be provided to include supplements, such as selenium, copper, and zinc, and vitamins A, D, and E, which improve leukocyte function against mastitis-causing bacteria.

Regarding the length of the dry period, first-lactation cows should be given 50–60 days, whereas multiparous (given birth more than once) cows can do well with 35–45 days. Also, by milking the higher-producing multiparous cows longer (e.g., giving them a 45- vs. 60-day dry period), yield will be lower when it is time to dry them off, they will leak less after the last milking, and will be less likely to develop mastitis.

Lastly, vaccination against environmental mastitis at dry-off has been instrumental in reducing the development coliform mastitis at calving and early in the subsequent lactation. Research has shown that clinical mastitis cases are reduced at calving by up to 80% by immunization with one of the commercially available coliform vaccines. In addition, it has been shown that vaccination returns about $57 per cow per year, and vaccination is profitable when greater than 1% of a herd has clinical coliform mastitis. The fact that 30–40% of all U.S. dairy cows are currently immunized with coliform vaccines suggests that the program has been successful. It must be emphasized, however, that vaccination does not overcome poor environmental conditions, housing, or nutrition over the dry period.

Summary

Research has demonstrated that proper dry-off methods are vital in promoting udder health during the nonlactating period and at calving. For high producing cows, it may be necessary to decrease dietary energy over the last one to two weeks of lactation by increasing fiber and eliminating grain. Abrupt cessation of milking is probably as good as intermittent milking with a diet change for low and medium producing cows; however, intermittent milking is recommended for high producing cows to decrease milk yield and minimize leakage of milk at dry-off, which could lead to mastitis. First-lactation cows should be given a 50- to 60-day dry period, but multiparous animals fare well with a 35- to 45-day dry period. Selective dry cow therapy with nonlactating cow antibiotics plus teat seal is as effective as blanket dry cow therapy with nonlactating cow antibiotics plus teat seal for cows with SCC less than 200,000/ml. However, blanket dry cow therapy with both products is recommended for cows that dry off with SCC > 200,000/ml. It is imperative to follow recommended infusion techniques to preserve the protective components of teat canal keratin and the sphincter muscle. And lastly, use of coliform vaccines will enhance immunity over the dry period and reduce clinical coliform mastitis in early lactation.

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