Dairy Split Session II

(Co-sponsored by National Mastitis Council)

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Teat Dips and the Practitioner

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Introduction

Control of bovine mastitis is predicated on a reduction in the rate of udder infection and a decrease in duration of existing udder infections.[10] The duration of udder infection is affected by therapy, spontaneous cure, death and culling. Rate of udder infection is affected by udder hygiene practices, milking procedures and milking machine function.[10] Emphasis will be given to udder hygiene practices in this paper, particularly postmilking teat antisepsis.

Udder hygiene is a 24-hour hygiene program and is probably the most cost effective mastitis prevention procedure available. Effectiveness of udder hygiene depends on maintaining minimum bacterial load on the teat because the rate of udder infection is highly correlated with the number of pathogens on the teat. The 24-hour hygiene program can be divided into three phases—between milking, premilking and postmilking. The between milking phase often receives the least attention although it accounts for most of the 24 hour period.[12] The rule for between milking management is simple: Keep cows clean, dry and comfortable!

Premilking hygiene has been associated with quality milk production more than mastitis control until recently. Attachment of a milking machine to a dry udder with clean and dry teats is paramount to the production of both quality milk and mastitis control.[5] Predipping, with good-udder-preparation (GUP) reduced rate of infection by environmental mastitis pathogens approximately 50% compared to GUP alone.[15] Post milking teat dipping and dry cow therapy were practiced on all cows in these studies. These recent studies[5,15] indicated that predipping with 0.5 to 0.1% iodine based teat dips aided in the control of mastitis caused by environmental pathogens.

Contagious mastitis pathogens, most commonly *Staphylococcus aureus* and *Streptococcus agalactiae*, are controlled with postmilking teat dipping and other good management practices.[10,14] The practice of sanitizing teats after milking was specifically designed to reduce bacterial load on teats after milking because teats were heavily contaminated with pathogens from infected quarters during milking.[10,11] Effectiveness of predipping on incidence of mastitis with contagious pathogens has not been reported.

History and Development

In 1916, Moak[9] suggested the use of a pine oil solution to aid in the control of *Str. agalactiae* mastitis. The practice was not widely adopted because of ineffective products and lack of supportive data. In the late 1950's Newbould and Barnum[11] determined the value of postmilking teat antisepsis in the control of mastitis caused by *Staph. aureus*. Throughout the 1960's, Dodd and coworkers[2] conducted three major field trials in England to evaluate postmilking teat antisepsis and dry cow therapy. These studies demonstrated conclusively the effectiveness of post milking udder sanitation in the reduction of udder infections with contagious pathogens.[2,10] Numerous research papers have concurred with these earlier findings and are reviewed.[14] Incidence of new udder infection generally was reduced from 50 to 90% by teat dipping.

The market for teat dips expanded tremendously as the practice of teat dipping was adopted throughout the dairy industry. A wide variety of products are currently available and range from the halogens to naturally occurring fatty acids. Efficacy, the ability to reduce the rate of intramammary infection (IMI), is the only appropriate test for evaluation of teat dips. The safety of teat dips for cow and man should also be determined. The National Mastitis Council developed and recommended experimental protocols to determine teat dip efficacy based on reduction in the rate of new IMI.[14] Utilization of either protocol can lead to generation of valid data on the effectiveness of a teat dip product. Veterinarians and farmers should select teat dips for use that have proven effective under one, or preferably both, of these protocols.

Protocol B determines efficacy of a teat dip against specific mastitis pathogens under experimental challenge conditions. Mastitis pathogens, usually *Staph. aureus* and *Strep. agalactiae*, are grown in broth culture. A challenge suspension of these pathogens is prepared that contains approximately 50 million colony forming units/ ml. Immediately after removal of the milking machine, all four teats are immersed to a depth of approximately 40 cm in the challenge suspension. Within a few seconds, diagonal teats are dipped full length into the teat dip being tested. The other two teats are not dipped and serve as controls. Teats are challenged with the pathogens to simulate bacterial load on teats after milking and to increase the number of pathogens on the teat end to increase the rate of udder infection. Quarter milk samples are collected weekly and analyzed bacteriologically and cytologically to diagnose udder infections. Some advantages of Protocol B are listed:

1. minimize variables that could effect teat dip efficacy;
2. determine efficacy against **specific** pathogen(s);
3. determine efficacy in 4 to 8 weeks;
4. know previous bacteriological and cytological histories of experimental cows.

Some disadvantages of Protocol B include:

1. can not be compared to on-farm efficacy tests;
2. requires a dairy herd that can be challenged;
3. does not determine effect of season of the year;
4. requires special laboratory equipment; and
5. number of organisms is probably greater than experienced under natural conditions and all effects of experimental challenge have not been determined.

Protocol C determines the efficacy of a teat dip under natural exposure to mastitis pathogens on a commercial dairy. The cooperator herd is usually divided into two groups that are balanced according to lactation, stage of lactation and bacteriological status of quarters. One group is dipped with the product under evaluation and the other group is the undipped control. Good dairy management procedures are practiced during the study in an effort to minimize the influence of these procedures on teat dip efficacy (milking procedures, milking equipment function, bedding condition etc.) Duplicate quarter milk samples are collected bimonthly and analyzed to confirm new udder infections. These studies also provide an opportunity to evaluate seasonal effects on efficacy and safety. Some of the advantages of Protocol C include:

1. determines efficacy under commercial dairy conditions for all seasons;
2. determines effect of lactation and stage of lactation;
3. between herd variation can be determined when multiple herds are used;
4. does not require a herd that can be challenged nor special laboratory equipment;
5. can evaluate effectiveness against all pathogen types present within a herd, if sufficient IMI are confirmed; milker acceptance can be evaluated;
6. safety to teats can be subjectively evaluated in all seasons.

Some disadvantages include:

1. impossible to monitor every milking to assure proper conduct of treatments and good management procedures;
2. for evaluation against contagious pathogens, requires a "problem herd", 15% to 30% infected cows, to be a "research associate" in the scientific evaluation of a teat sanitizer;
3. cannot control types of mastitis pathogens; and
4. usually requires a minimum of 12 months to obtain sufficient numbers of IMI for valid statistical analysis.

The validity of results from each of these two protocols is taunted by "experts" based on personal interpretation and emphasis of specific advantages or disadvantages respectively. Either protocol can provide repeatable and reliable data that better assure veterinarians and farmers of product effectiveness to reduce the rate of udder infection.

Summation of a number of studies provides some insight into the degree of data agreement between these two different methods to develop efficacy data on postmilking teat sanitizers.[14] At least six teat dips have been evaluated under both Protocol B and Protocol C. Comparison of efficacy data for these six products indicates very similar results. Four teat dip formulations effective by procedures of Protocol C were also efficacious by Protocol B. A 1% iodine-in-oil product did not reduce infection rate of *Staph. aureus* under natural or experimental challenge conditons. Studies with a .5% iodine-in-oil formulation were of particular interest. Rate of infection with *Staph. aureus* was increased in both natural and experimental challenge. Additionally, infections with *Strep. agalactiae* were reduced marginally under both natural and experimental conditions. Experimental challenge trials reflected both the enhancement of IMI with *Staph. aureus* and the difference in efficacy with respect to the two pathogens. Either protocol can lead to development of meaningful data. A thorough review of postmilking teat antisepsis was published in 1984[14] and lists efficacy data on numerous formulations of different classes of products.

Teat Dip Classes

Iodophor teat dip formulations are the most common class used throughout the world. An iodophor teat dip is a combination of iodine and a complexing agent or carrier molecule. Iodophor dips are formulated to contain 0.1 to 1.0% iodine. The US is the only country to market 1% iodophor teat dips. The germicidal active ingredient is the

"free" iodine, I_2, that is in equilibrium with, but not bound to, the complexing agent. The mode of action is chemical and not biological. Bacteria are destroyed by an oxidation-reduction mechanism that "burns up" the bacteria. The killing action is fast.[16] Perhaps the singular greatest advantage of iodine based dips is that these are recognized as excellent broad spectrum germicides. Some disadvantages include: 1. acrid odor, 2. staining, 3. possible irritation of teat epidermis, dependent on formulation, and 4. possibility for residues in milk. Emollients are commonly included in formulations with the intent to enhance teat skin condition. Glycerin is a common additive in the range of 2% to 10%. Lanolin and sorbitol are also possible emollients used to aid in teat skin conditioning. Research data are lacking that demonstrate effects of any teat dips on bovine teat epidermis condition. As discussed earlier,[14] iodine-in-oil was determined a high risk product under defined conditions. Incorporation of nonlabel skin conditions should be practiced prudently. Inactivation of the germicidal agent(s) is a probability for iodines and other classes of teat sanitizers. Use as directed.

Chlorhexidine ___ [1, 6-di-(4-chlorophenyldiguanido) hexane] teat dips are probably the second most popular products internationally. This class of product is a colorless, odorless base. The salts are moderately to freely soluble in water. Formulations of 0.5% are the most frequently used. A dye is added to enhance visibility. Chlorhexidine is rapidly absorbed onto bacterial cell walls. Mode of action can be through cell lysis or precipitation of proteins and nucleic acids.[8] Some advantages given for chlorhexidine teat dips include: 1. broad spectrum activity against numerous gram positive and gram negative bacteria; 2. less reduction in germicidal activity by organic material than other classes; and 3. persistence of activity on teat skin reportedly greater than other germicides.[14]

Some disadvantages listed include: 1. some skin irritation can occur and 2. contamination has been reported for specific chlorhexidine formulations by *Serratia* spp. and *Pseudomonas* spp.[14]

Glycerine is commonly used as an emollient and should be incorporated at concentrations indicated by the manufacturer to prevent reduction of germicidal activity.[14]

Linear dodcecyl benzene sulfonic acid (LDBSA) was one of the additional chemical classes of teat dip developed following the halogen and chlorhexidine products. LDBSA is an acid-anionic surfactant, a detergent type compound. Optimal germicidal activity is near pH 3.0. Most LDBSA products contain glycerine in the range of 12% as a skin conditioner. Mode of action is postulated to be through inactivation of essential enzymes, general denaturation of proteins, or disruption of cell membranes resulting in alteration of permeability.[3] Some advantages include: 1. nonstaining, 2. low toxicity, and high tolerance for organic matter. Some disadvantages given include: 1. limited effectiveness against gram negative bacteria at pH levels above 3.5.

Other Teat Dip Types include barriers, chlorine dioxide, fatty acids and many more. The barrier- type dips were developed to aid in the control of mastitis caused by environmental pathogens, including *E. coli* and nonagalactiae streptococci. Field studies reported that the true barrier products were beneficial in reducing IMI by the environmental pathogens.[4] Field experiences have suggested that prolonged use of barrier dips can lead to increased incidence of IMI by contagious pathogens, primarily *Staph. aureus* or *Strep. agalactiae.* Milk quality parameters should be monitored very closely when barrier dips are utilized for extended periods. One recommendation is to use the barrier dip when environmental conditions appear to predispose IMI by the coliforms and other streptococci and use conventional germicidal products otherwise.

A few manufacturers are in developmental stages with teat dip formulations containing "naturally occurring" germicides. Compounds commonly associated with the udder or milk that possesses bacteriostatic or bactericidal properties; fatty acids are one example of this new generation of products.

The effects of sanitizers on teat epidermis has not received much attention though many companies make claims on the teat toning properties. Histological studies on teat epidermis are in progress at the University of Vermont. Some techniques for histological analysis have been developed and evaluated. Work continues to determine "normal" parameters for teat epidermis, effect of routine management practices on teat epidermis, and the significance of these changes on susceptability to IMI.

Residues in Milk

Residues in milk that result from the application of any teat sanitizer must be avoided. Galton et. al.[6,7] determine that postmilking teat dipping with iodine based dips caused residue in milk, but well below levels tolerated by regulatory agencies. Presumably, the product was absorbed into the teat epidermidis during the between milking period.

Residue data are not available for noniodine teat sanitizers or for the other components of iodine teat dip products. Microanalytical techniques have not been applied successfully for analysis of parts/billion level for these components. Iodine levels have been determined because methods of analysis are relatively easy to conduct. In fact, milk is contaminated by application of any sanitizer, either before or after milking. The main issues are "residues" and "safety." Teat dip components generally include: 1. active germicide, 2. emollients and skin moisturizers and possibly 3. other ingredients such as surfactants, stabilizers,

food grade dyes, or viscosity regulators. All of these components can cause "residues" in milk, but most important, should be "safe" for consumer, cow and operator. In many cases, all ingredients of a teat sanitizer have been cleared, or are approved by the Food and Drug Administration (FDA) as direct or indirect food additives, or designated as substances "generally recognized as safe" (GRAS). The "ideal" teat dip would be formulated with FDA "cleared" or GRAS ingredients that effectively reduces rate of IMI.[13] Teat dip manufacturers should develop efficacy and residue data or use FDA approved ingredients to assure effective and safe teat sanitizers for dairy farmers. Farmers should demand these data before using a product.

Summary

Udder hygiene is probably the most effective, efficient and economical management procedure to control mastitis. The essence of a 24-hour hygiene program is to keep cows clean, dry and comfortable. In 1946, Bryan et. al[1] wrote "Proper stall hygiene is a prerequisite to udder hygiene." Milking cows with dry udders and clean, dry teats is the basis for milking time hygiene. Postmilking teat antisepsis was developed and proven an effective tool in the control of contagious mastitis pathogens. Numerous teat dip formulations are marketed. Reliable protocols are available for development of efficacy data. Veterinarians and farmers should require manufacturers to provide proof of effectiveness from controlled research before using a product. All iodine based products are **not** equally effective! Formulation differences do alter efficacy. Demand data from controlled research. Emollients are incorporated to minimize irritation and to promote teat skin condition. The value of these additives to teat skin has not been documented. Residues in milk will always be a potential problem and everyone in the dairy industry must practice procedures that assure production of high quality milk.

The question most frequently asked is "What is the best teat dip?" One answer is a product proven to reduce rate of IMI by the mastitis pathogens present in your herd situation, that is safe to cow and milker, that leaves no residues unsafe to consumer, produced under "good manufacturing practices" and properly labeled according to the FDA. The act of dipping teats is far more important than "which" dip. Many teat sanitizers have good efficacy data generated in controlled studies and all of these have the potential to effectively aid in the control of mastitis within any dairy herd. Improper use or poor management practices can negate all positive effects. Udder hygiene is only one component, and a most important one, of a total mastitis control program. A total control program should be implemented to maximize efficient production and profitability.

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