

# **A COMPREHENSIVE PLAN TO CONTROL MASTITIS AND MILK QUALITY**

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## **ABSTRACT**

The prevalence of mastitis in any dairy herd is a function of the rate of new intramammary infections and the duration of those infections. The rate of infection is decreased by utilization of proper milking hygiene, properly functioning milking machines, and teat dipping, while the duration of infection is controlled by treatment of infections and culling. Dry cow therapy controls both the rate of infection by preventing new mastitis cases and curing existing cases during the nonlactating period. As the rate of new infection is reduced by using the proper control measures, the prevalence of mastitis will fall to a new equilibrium, and as the duration of infection is reduced through treatment and culling, the level of mastitis can be reduced to a minimum.

## **INTRODUCTION**

The dairying world is indebted to a team of dedicated and imaginative mastitis researchers, led by Dr. F. H. Dodd of the National Institute for Research in Dairying in England, who conducted a series of field trials in the 1950s and 1960s that enabled dairy specialists everywhere to better understand the dynamics involved in mastitis control. They demonstrated that mastitis ebbs and flows within an individual dairy herd, and that the pattern of mastitis changes when a control system is introduced that is of benefit in controlling certain pathogens, thus necessitating changes and/or additions to the control program to better control other pathogens.

## **PROGRESS IN MASTITIS CONTROL**

Over the past 40 years, and especially during the past 25 years, significant progress has been made in reducing the prevalence of mastitis in countries with developed dairy industries. This fact is evidenced by herd and laboratory surveys, as well as by reductions in somatic cell counts (SCC) and the incidence of clinical mastitis. The incidence of clinical mastitis has decreased from 121 cases per 100 cows in 1968 to fewer than 45 in 2008. Progress has occurred even though: (1) mastitis control programs have not been universally applied in a conscientious and consistent manner; (2) dairy herds have become larger; and (3) milk production per cow has essentially tripled since 1955. Nevertheless, prevalence of subclinical mastitis present in the typical dairy herd has decreased approximately 50% in most countries, and the prevalence has decreased consistently 80 to 90% in many herds where recommended mastitis control methods were consistently applied over a long period of time.

It is well established that the number of mastitis pathogens impinging on teats of cows tends to increase as herd size increases because of the increase in environmental microbial concentrations. Moreover, researchers have determined that high producing cows are more

susceptible to intramammary infection than low producing cows. Thus, the dairy industry can take pride in the progress that has been made in mastitis control to date, but many challenges remain to: (1) develop even more effective control methods for specific pathogens; and (2) enhance adoption by dairy farmers of control methods that are presently available.

Significant progress has been made in eradicating mastitis caused by the contagious pathogen *Streptococcus agalactiae*. This organism: (1) is an obligate parasite of the bovine udder, which means it cannot survive for extended periods of time outside the mammary gland; (2) normally does not cause extensive scar tissue formation in an infected gland, which makes treatment in lactation more effective; and (3) is universally sensitive to penicillin. Progress has also been made in reducing the prevalence and importance of *Staphylococcus aureus*, which is also a highly contagious organism. Unfortunately, this organism continues to be the most prevalent major pathogen in many dairy herds because of its ability to: (1) survive at multiple sites away from the bovine udder; (2) cause extensive scar tissue formation in infected glands, which aids in protecting the organisms from drugs; and (3) develop resistance to certain drugs.

There has also been a slight reduction in the prevalence of mastitis caused by environmental streptococci such as *Streptococcus uberis* and *Streptococcus dysgalactiae*, though their relative importance in the mastitis complex has increased as a result of the reduction in prevalence of the contagious pathogens *Streptococcus agalactiae* and *Staphylococcus aureus*.

### **WHY DOES MASTITIS STILL EXIST**

The continuing presence of mastitis in dairy herds may be attributed to: (1) deficient management practices; (2) improper milking procedures; (3) faulty milking equipment, though this problem is not nearly as important as in the past; (4) inadequate housing; (5) unsanitary environmental conditions; (6) failure to implement proven mastitis control methods; and (7) breeding for ever-increasing milk yield. All of these factors, and other factors not yet identified, are probably involved in predisposing cows to mastitis, though field studies often fail to incriminate specific factors.

When mastitis organisms are combined with factors that enhance susceptibility of individual cows, subclinical mastitis often develops. Four things can occur at this stage: (1) the disease may remain subclinical; (2) it may be eliminated by antibiotic treatment; (3) the infection may be eliminated spontaneously by immune defense mechanisms of the cow; or (4) it may progress to clinical mastitis. When mastitis becomes clinical, any of several things may occur: (1) antibiotic treatment may eliminate the infection; (2) antibiotics may force it back to the subclinical state; (3) the affected cow may be culled from the herd; or (4) the cow may die.

It is important for dairy farmers and other workers in the dairy field to recognize that mastitis is a multifactorial disease that often results from the interaction of many environmental and

management factors that: (1) increase exposure of cows to mastitis pathogens; (2) reduce the natural resistance of cows to disease; and/or (3) aid organisms in gaining entrance through the teat canal into the mammary gland where they cause mastitis. Because modern dairy cows are entirely dependent on people for their care and well being, it is essential that everyone associated with them make a conscientious effort to: (1) provide the best possible management; (2) provide excellent environmental hygiene; (3) use proper milking procedures; and (4) conscientiously apply recommended mastitis control methods.

### **OBJECTIVES OF A CONTROL SYSTEM**

If mastitis control methods are to be acceptable to dairy producers, they must: (1) return a profit; (2) be practical and easy to use on a continuing basis; (3) be effective under a wide range of management and environmental conditions; and (4) reduce the incidence of subclinical and clinical mastitis.

The reduction of clinical mastitis is often the first prerequisite of dairy producers because they recognize the clinical form of the disease and the economic consequences associated with its presence, while the subclinical form is more easily tolerated because of the absence of overt symptoms. Fortunately, increased awareness by producers in recent years concerning the relationship between: (1) SCC and quality premiums; (2) presence of subclinical mastitis; and (3) milk losses has helped focus their attention on this disease. It is also fortunate that the view of producers that clinical mastitis be reduced is not in conflict with other objectives of a mastitis control program because much clinical mastitis is first preceded by mastitis at the subclinical level. The incidence of clinical mastitis is more closely related to incidence of new infections than to level of infection. Thus, a reduction in clinical mastitis is evidence that the subclinical form is also being reduced.

### **THE BASIS OF SUCCESSFUL CONTROL METHODS**

Mastitis is different from other cattle diseases such as brucellosis and tuberculosis because it is multifaceted and the main aim is control rather than eradication. The individual herd is the unit of control, and the level of mastitis in the herd is independent of the level in nearby herds. Thus, the primary need is not for a national mastitis control program, but for a herd control program applied nationally.

The primary principal underlying all efforts to control mastitis is prevention of infections. In absence of methods for preventing all new infections, two main approaches to mastitis control may be followed. The first approach is based on individual herd investigations to confirm the extent of intramammary infections to provide: (1) information for treating or culling specific cows; and (2) to try and identify specific factors responsible for the high level of infection. This approach is often essential when immediate action is required in crisis situations because of a: (1) high SCC in herd milk; (2) high incidence of clinical mastitis; or 3) bacteria count caused by mastitis organisms. However, such a program is clearly impractical for all herds on a national basis because it is expensive and has little chance of reaching more than a minority of dairy herds.

Though laboratory examination of milk samples from individual cows will reveal the types of organisms, and the relative importance of each type, the information usually will be of limited value in determining what corrective steps should be taken. The most notable exception is when the objective is eradication of *Streptococcus agalactiae*. Even this objective will be more easily realized if supported by measures designed to guard against reinfection. Also, eradication can be achieved without laboratory cultural assistance, but the process will require more time.

The second and more practical approach to mastitis control is to follow a regimen that the dairy producer can apply without need for information on type of infection or individual quarters involved. Such a program should: (1) be effective in most herds; (2) be simple to apply under a wide range of circumstances; and (3) not require investigations or on-site assistance from specialists. Fortunately, a suitable control program was developed by scientists in England in the 1960s, which has been further refined by researchers and other specialists in many other countries throughout the world.

### PRINCIPLES OF MASTITIS CONTROL

Controlling mastitis is not a matter of doing just one thing. Instead, it involves following a number of steps frequently referred to as a control program. Such a program must: (1) prevent a substantial percentage of new infections; (2) eliminate a majority of infections after they develop; and (3) be subject to easy modification as improved control methods are developed through research.

For practical reasons, the effectiveness of a mastitis control program is measured in terms of level of infection in a dairy herd. The level of infection is a function of two things: (1) rate of infection; and (2) duration of infection. Rate refers to the frequency with which new infections develop, while duration refers to how long infections persist before being eliminated from the herd. If the rate of infection is reduced, the level will fall to a new equilibrium, and the time taken to reach the new level will be the average duration of the infections. Factors affecting level of infection may be simplified as follows.

A		B		C		
Average level of infection (% of cows infected)	=	Total cows infected in period (% of total cows)	X	Average duration of infected cows remain infected (% of period)	X	100

Data from a large field trial in England involving commercial herds revealed that A = 56% of cows and B = 80%. By calculation, the duration, C, must have been 70% of the period. However, if either B or C could be reduced by 50%, the level, A, would fall by 75%. These figures indicate that effective control could be obtained with modest reductions in both rate of new infection and duration of infection.

Most dairy producers have reduced the level of mastitis in their herds by following all or part of widely recommended control programs. However, the vast majority of producers can reduce the level of mastitis further. The effect of even modest reductions in rate and duration of infection can be seen in Table 1. For example, if both rate and duration are reduced by just 10%, the level of infection will decrease by 19%. Even a casual inspection of Table 1 will demonstrate that greater reductions in level can be expected if either rate or duration are reduced beyond 10%. For example, if rate is reduced 50% and duration is reduced 40%, the level will decrease by 70%.

It must also be emphasized that if an effective control program is initiated and infections decrease to a new level, that level will not be maintained unless steps are taken to continue to reduce both rate and duration of infection in the future. If B or C in the equation above increases, there will be a proportional increase in level of infection. Also, relationships discussed above do not give any indication of the time required for the reduction in level of infection to occur. A control program relying only on reducing new infections would act slowly because of the high average duration of infections. This was confirmed when British researchers who observed that a 50% decline in new infection rate reduced the level of infection only 12% in 1 year. The reason for this can be seen by expanding the B term in the equation.

B		D		E
Total cows infected in period (% of total cows)	=	Cows infected at start of period (% of total cows)	+	Cows uninfected at start becoming infected in period (% of total cows)

Data from the field experiment in commercial herds revealed that B = 80% of cows, D = 56%, and E = 24%. Therefore, if a preventive program had been 100% effective and no new infections had occurred, the total cows infected would have declined by less than one-third during a 12-month period. With any control system designed to reduce staphylococcal and streptococcal infections, the rate of decline of infection in the first year after a control program is applied will depend much more on reduction in duration of infection than on reduction in the rate of new infections.

Up to this point, we have been concerned only with factors affecting level of infection. It is now appropriate to consider separately the principles that must be taken into account in reducing the development of new infections (rate) and eliminating existing infections (duration).

## **METHODS OF REDUCING NEW INFECTIONS**

The influence of management on mastitis can be divided into factors that: (1) influence exposure of cows to mastitis pathogens, such as bedding management in the environment and use of disinfectants in the milking parlor; and (2) factors that affect penetration of pathogens through the teat canal and into the udder. The most effective procedure developed to date for preventing new infections involves: (1) dipping teats before milking to aid in controlling infections caused by environmental pathogens such as *Streptococcus uberis*; and (2) dipping teats after milking to aid in preventing infections caused by contagious pathogens such as *Streptococcus agalactiae* and *Staphylococcus aureus*. Both procedures will reduce infection rates with the target organisms by approximately 50%.

### **ELIMINATION OF INFECTIONS**

Existing infections can be eliminated from a dairy herd by: (1) spontaneous recovery; (2) antibiotic treatment; and (3) culling. Again, the field trials in commercial dairy herds in England provided valuable information on the proportions of infections eliminated by each of the three methods. About 20% of all infections found in 1 year disappeared spontaneously and only 29% of infections were eliminated by treatment administered to clinically affected quarters detected by persons handling and milking the cows. The main reason for the ineffectiveness of lactation therapy was the fact that only 40% of infections detected by laboratory culture became clinical. Thus, it is clear from these data that even if more effective drug formulations are developed for use in lactating cows, the control of mastitis by treating clinical cases will not achieve the necessary reduction of infection because only a relatively small percentage of infections are detected by clinical symptoms.

The above findings led to the development of highly effective, slow-release antibiotic products for use in treating every quarter of every cow at drying off. This practice, known widely as “routine dry cow treatment” is far more effective than lactation treatment for the reasons listed below.

- Every infected quarter is treated.
- The cure rate is higher than when administered during lactation.
- Higher concentrations of long-acting antibiotic formulations can be used.
- The incidence of new infections during the dry period is reduced significantly.
- Clinical mastitis at freshening is reduced.

### **THE COMPREHENSIVE PLAN OF MASTITIS CONTROL**

The pioneering research conducted in England in the 1950s and 1960s has been augmented by a tremendous amount of additional research conducted at numerous research centers in the United States and in many foreign countries. That research has helped to enhance understanding of the complexities involved in the control of this formidable disease. Using those findings, the authors have formulated a control program that has been shown to be effective in the vast majority of dairy herds when conscientiously applied. This program is subject to easy modification when new research findings warrant and is referred to as The Comprehensive Plan of Mastitis Control. It contains six basic points that will be discussed

briefly.

### **Point 1. Proper Milking Hygiene**

The basic objective with good milking hygiene is to milk teats that are both clean and dry. This is important because the milking of clean, dry teats not only aids in reducing the incidence of new infections, it also helps to ensure the production of high quality milk with a minimum of microorganisms that will improve the quality of processed dairy products. A minimum amount of water or sanitizing solution should be used to prepare teats and udders for milking. Teats should be dried thoroughly before teat cups are attached, preferably with an individual paper or cloth towel. An alternative procedure that has gained wide acceptance is the practice of predipping, whereby teats are dipped with an approved predip product. Following the recommended contact time, teats are dried carefully to prevent germicide residues from getting into the milk.

### **Point 2. Use of Functionally Adequate Milking Machines**

Research has confirmed that the milking machine can be: (1) a vector for transferring mastitis organisms from teat to teat and from cow to cow; and (2) a means of transferring those organisms through the teat canal. Fortunately, this problem is not as important as it was in the past. Every effort should be made to ensure that milking machines meet functional standards, which include a few simple, but very important points listed below.

- Make certain milking systems meet internationally accepted design and installation standards.
- Provide a relatively stable milking vacuum level of 11 to 12 inches (275 to 300 millimeters or 37 to 41 kilopascals) of mercury at the claw during peak milk flow.
- Avoid slipping or squawking teat cup liners during milking.
- Shut off vacuum to the claw before removing teat cups.

### **Point 3. Dip Teats After Milking**

The transfer of some mastitis pathogens is inevitable at milking time, even under the best of hygienic conditions. To destroy microorganisms remaining on teats at the end of milking, it is necessary to use some form of postmilking teat hygiene. The most widely used procedure involves dipping teats with a suitable disinfectant soon after milking machines are removed.

Extensive research has been conducted on a wide range of teat dips. The vast majority of products on the market in the United States reduce the rate of new infection by more than 50% when used properly in conjunction with other components of The Comprehensive Plan of Mastitis Control. It is recommended that the portion of the teat touched by the teat cup liner, which usually translates to the entire barrel of the teat, be covered by immersion or by spraying. Teat dipping is preferred as opposed to teat spraying because most persons who milk cows only spray one side of the teats, though we are quick to admit that our research shows that teat spraying can be as effective as teat dipping — if the entire surface of each

teat is covered with spray. Unfortunately, this is rarely done in practice.

#### **Point 4. Treat All Quarters at Drying Off**

The treatment of every quarter of every cow with a specially formulated, long-acting, commercially available, dry cow treatment product is recommended. Benefits of this practice were discussed above.

#### **Point 5. Treat All Clinical Cases Promptly**

In order for this practice to be effective, it is imperative that all dairy personnel be conscientious about detecting clinical cases and initiating appropriate treatment as promptly as possible. The full series of recommended treatments should be administered using proper procedures and precautions taken to avoid presence of drug residues in herd milk.

#### **Point 6. Cull Chronically Infected Cows**

Cows that do not respond favorably to treatment, and which continue to flare-up repeatedly with clinical mastitis should be culled promptly. Their continued presence in the herd may result in other cows becoming infected.

Each of the six points listed in The Comprehensive Plan of Mastitis Control complement each other as shown in Table 2. Four of the points reduce the rate of infection, while three of the points reduce the duration of infection. Dry cow therapy of all quarters of all cows not only reduces the duration of existing infections, it also reduces the rate of infection by preventing the development of new infections in the early dry period.

Emphasis on The Comprehensive Plan of Mastitis Control should not be interpreted as indicating that other management practices are not important, because this is not the case. For example, hygiene in the cows' environment is of extreme importance, regardless of whether the cow is: (1) in confinement housing; (2) in a corral; or (3) on pasture. Also, numerous other management considerations are important. Included are such things as: (1) management of cows in the dry period; (2) source of herd replacements; (3) dietary supplementation; (4) a vaccination program for coliform mastitis in herds where the practice is appropriate; and (5) methods for preventing or controlling stress.

It should also be emphasized that herd replacements are often an important source of mastitis pathogens in a dairy herd. Before purchasing herd replacements, it is recommended to culture quarter or composite samples from individual cows. Finally, heifers raised on the farm may be an important source of mastitis organisms, and it may be necessary to initiate a program for treating heifers prepartum. It has been shown that up to 50% of the *Staphylococcus aureus* infections present in lactation in some herds entered the herds via first calf heifers that were infected at parturition.

## MASTITIS CONTROL IN THE FUTURE

Basic research is continuing on many facets of mastitis control, and it is highly probable that some of the studies will result in new and effective approaches to control this disease. These will likely include, but may not be limited to: (1) use of biotechnology to design vaccines; (2) improved methods for identifying specific mastitis pathogens; (3) improved antimicrobials that penetrate scar tissue and are more effective in killing microorganisms; (4) development of more effective germicides; (5) breeding dairy cattle that are more resistant to mastitis; and (6) use of immunostimulants that enhance resistance to mastitis pathogens.

## CONCLUSIONS

Mastitis can be controlled in any dairy herd by following recommended practices that reduce both the rate and duration of infection, collectively named a Comprehensive Plan of Mastitis Control. This plan includes proper milking time hygiene, use of adequately functioning milking machines, pre- and postmilking teat antiseptics, dry cow therapy, lactation therapy of clinical mastitis, and culling of chronically infected cows that do not respond to therapy. Emphasis on this plan does not suggest that other management practices are not important. For example, hygiene in the cows' environment is of extreme importance, regardless of whether cows are in confinement housing, corrals, or on pasture. Other management considerations include management of cows during the dry period, source of herd replacements, dietary supplementation, a vaccination program for coliform mastitis, and methods for controlling stress.

**Table 1. Effects of reducing rate and duration of infection on level of infection.**

% Reduction in		
Rate of infection	Duration of infection	Total reduction in level of infection (%)
0	0	0
10	10	19
20	20	36
40	30	58
40	40	64
50	40	70
50	50	75
60	60	84

**Table 2. Effects of the six points in the Comprehensive Plan of Mastitis Control on rate and duration of infection.**

Control component	Infection dynamic controlled
Proper milking hygiene	Rate
Good milking machines	Rate
Teat dipping	Rate
Dry cow treatment	Rate <sup>1</sup> and duration
Treatment of clinical mastitis	Duration
Culling	Duration

<sup>1</sup>**Dry cow treatment also has an effect on rate of infection by reducing new infections in the early dry period.**

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