Winter Evaluation of a Postmilking Powdered Teat Dip

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ABSTRACT

A powdered teat dip designed for winter usage was evaluated for bacteriological efficacy and teat conditioning qualities. A positive control, natural exposure field trial was conducted for 3 mo on 509 lactating cows. Two sets of cows, primiparous and multiparous, were used. The trial compared efficacy of a powdered teat dip with a teat dip of 1% iodine plus 10% glycerin.

Bacteriological efficacy among primiparous cows was equivalent for all major mastitis pathogens, environmental pathogens, and streptococci other than *Streptococcus agalactiae*. Efficacy was not equivalent against coagulase-negative staphylococci and all mastitis pathogens. Results suggested that the positive control product was more efficacious.

Among multiparous cows, efficacy was equivalent against environmental mastitis pathogens and bacteriologically negative, clinical mastitis. The products were not equivalent against *Staphylococcus aureus*, coagulase-negative staphylococci, or all major mastitis pathogens, once again suggesting that the positive control product was more efficacious. Data indicated that germicidal activity of the powdered dip was not sufficient to reduce the incidence of new IMI caused by contagious or minor pathogens normally associated with teat skin.

Application of a powdered postmilking teat dip during 3 winter mo in Idaho resulted in improved teat end condition among primiparous and multiparous dairy cows. Teat skin condition improved among primiparous but not among multiparous cows.

(**Key words**: teat condition, corn starch, powdered teat dip, postmilking teat sanitizer)

Abbreviation key: **CM** = clinical mastitis, **CNS** = coagulase-negative staphylococci, **LLCI** = lower limit confidence interval, **NMC** = National Mastitis Council.

INTRODUCTION

The major objective of udder hygiene is to minimize the number of mastitis pathogens on teats to reduce the risk of new IMI (7). Under conditions of severe cold or wind, postmilking teat dipping with improperly formulated teat dips may facilitate teat chapping (7), resulting in increased colonization by the staphylococci that are normally associated with teat skin (2). When teats were experimentally chapped via submersion in 1*N* NaOH, treatment with teat dips of 1% iodine plus 10% glycerin and of .5% chlorhexidine plus 4.87% glycerin elicited increased healing of the teats and fewer numbers of *Staphylococcus aureus* on teat skin than did treatment with a 1% chlorhexidine

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ointment. Application of ointment was marginally better than a no treatment control (2).

During cold weather conditions, in an effort to minimize teat chapping, many dairy farms do not apply conventional, water-based teat sanitizer after milking. Use of a powdered teat dip may aid in reducing teat chapping because the starch absorbs the surface water responsible for chapping (7). Several corn starch polymers have been developed that have superabsorbent capabilities (1). By utilizing these polymers to absorb aqueous secretions from wounds, some equine practitioners observed improved healing over conventional treatment approaches (10). This technology has been applied to udder hygiene programs on a limited basis. To date, only one powdered product has been marketed as a teat dip.

The objective of this study was to the evaluate efficacy and teat conditioning qualities of the commercially available Powdered Teat Dip & Frost Protectant® (IBA Inc., Millbury, MA) during cold weather conditions. The study was designed as a negative control, no postmilking teat dipping, natural exposure field trial (5).

MATERIALS AND METHODS

Cooperator Herd

C Bar M Dairy (Jerome, ID) was selected as a commercial herd cooperator and met the following criteria: 1) all cows had permanent, visible identification; 2) milking equipment conformed to 3A standards (6); and 3) owners agreed to follow procedures of the natural exposure protocol for studies to determine efficacy of a postmilking teat sanitizer. The study was conducted for 3 mo from December 9, 1991 through March 14, 1992 (Figure 1).

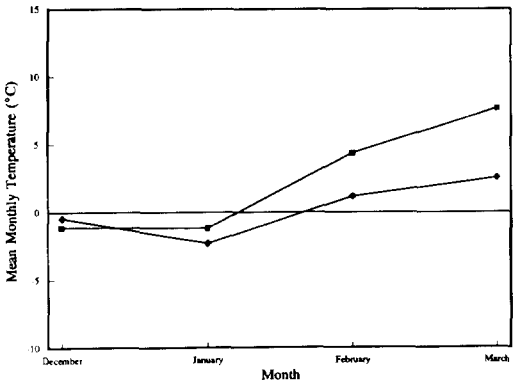

Figure 1. The USDA temperature summary, Twin Falls weather station, Kimberly, Idaho. Months of the study (■) and mean temperature for the previous 25 yr for December through March (♦).

Milking System and Procedures

Cows were milked by two operators in a double-12 herringbone parlor equipped with rapid exit gates. Cow throughput was approximately 100 cows/h. Cows were equipped with Conewango 1D-C1A inflations and were replaced every 21 d, which was approximately 1750 milkings. Automatic unit detachers were used as was a backflush system after detachment. Vacuum level was calibrated at 345.44 mm Hg. The alternating pulsation system had 52 cycles per min and a ratio of 60:40 milk to rest. The milking system was analyzed in December 1991 at the initiation of the trial.

Treatment Groups

Two split-herd experiments were conducted. Approximately 509 cows were divided into four groups. Two groups (treatment and positive control) were primiparous cows, and two were multiparous cows. Primiparous cows were placed in adjacent corrals to obtain a minimum of 120 cows per treatment group. Multiparous groups also had a minimum of 120 cows per lot. Lots were not adjacent. Groups were balanced for lactation number, DIM, and bacteriological status of quarters at initiation of the trial. An effort was made to include cows with <100 DIM to maximize the number of cows that remained on the study for the entire trial. Cows were added to the treatment groups to maintain numbers and were assigned randomly to maintain balance. Udder preparation procedures for the treatment groups were as follows. For group 1, teats were sprayed with a sanitizer (Bovadine II®, a .25% iodine product; West Agro Chemicals, Kansas City, MO) as cows entered the parlor. Contact time was at least 30 s for the premilking teat sanitizer before forestripping. Teats were dried thoroughly with multiple paper towels. Strategic washing, usually with addi-

tional spray applications of predip, was used to remove organic material from teats. Cows were milked in the routine manner. Powdered Teat Dip & Frost Protectant®, which contained allantoin from comfrey and stabilized ascorbic acid in an amylum base, was applied generously immediately after machine removal to cover as much of the teat surface as possible. The premilking udder preparation for group 2 was identical to that of group 1. Liquid postmilking teat sanitizer was not applied unless outside ambient temperature was ≤–6°C and wind was appreciable, as determined subjectively by the farm owners. Based on reports from the cooperator, at no time during the trial was postmilking teat sanitation suspended for more than 2 consecutive d. The postmilking teat sanitizer in the control group was Bovadine®, which contained 1% iodine plus 10% glycerin and was applied by immersion after machine removal. Powder dip was applied following every milking without interruption.

Collection of Milk Samples

All quarter milk samples were collected aseptically by recommended procedures (4). Bacteriological status of individual quarters was determined at initiation of the trial by collection and culture of single quarter milk samples. A second set of confirmatory samples was collected in duplicate when mastitis pathogens were isolated from the initial sample. All lactating quarters with uninjured teats were considered to be eligible for inclusion in the trial.

Single quarter milk samples were collected by laboratory personnel at initiation and termination of the study. Sample dates were December 12, 1991 and March 14, 1992. Additional quarter milk samples from all quarters were collected by the cooperator in duplicate for the following reasons: 1) cows that developed clinical mastitis (**CM**), 2) cows that entered the study within 3 d of parturition, 3) cows that left the study at dry-off, 4) cows prior to moving to other lots, or 5) cows prior to being sold. Cooperator-collected samples were cultured and read by a collaborating veterinarian. These primary plates were stored at 4°C and were forwarded monthly by 2-d delivery service to the Quality Milk Research Laboratory (University of Vermont, Burlington) for confirmatory identification.

Analyses of Milk Samples

Bacteriological analyses were conducted on all milk samples using recommended National Mastitis Council (**NMC**) procedures (4). Samples were plated on trypticase soy agar containing 5% washed bovine red blood cells with .1% esculin (Micro Diagnostics, Lombard, IL). A .01-ml aliquot of each quarter milk sample was streaked on one quadrant of a blood agar plate.

Clinical mastitis was evaluated once daily by the herd owner and coded as follows: CM1 = milk appeared slightly abnormal with only a few flakes; IMI was not diagnosed if quarter was bacteriologically negative. CM2 = Milk was visibly abnormal with flakes and clots. CM3 = Acute clinical mastitis; milk was grossly abnormal. CM4 = Peracute mastitis; milk was serumlike, and cow was systemically affected. All CM cases coded CM2, CM3, and CM4 were included in the data set when present in eligible quarters.

Identification of staphylococcal isolates was confirmed with the Staph Trac® Staphylococcus Identification System (Analytab Products, Plainview, NY). *Staphylococcus aureus* was confirmed also with rabbit plasma coagulase tests (Difco Laboratories, Detroit, MI). Streptococci were confirmed with the Phadebact ABCG Streptococcus Test Kit (Pharmacia Diagnostics, Pharmacia Inc., Piscataway, NJ), and the Rapid Strep® Streptococcus Identification System (Analytab Products, Plainview, NY). Monthly composite SCC were by a local milk testing service.

Diagnosis of IMI

An IMI was diagnosed by one of the following criteria: 1) isolation of ≥100 cfu/ml of a common mastitis pathogen from a clinical sample, 2) isolation of ≥500 cfu/ml of a pathogen from consecutive samples, and 3) isolation of ≤400 cfu/ml of a pathogen from three consecutive samples.

Teat End and Teat Skin Evaluation

At both of the routine samplings, teat ends and teat skin were evaluated on all teats of all

cows in the treatment lots. Evaluations were based on a subjective scoring system developed at the University of Vermont (Figure 2) for teat end (9) and teat skin (3) classifications. These scores were recorded and compared by treatment group to determine interactions between time and group using a general linear models procedure (8). Three comparisons were conducted on teat scores: 1) ANOVA on least squares means between treatment groups on sample date; 2) interactions within treatment group by time; and 3) interactions between treatment groups by time. All analyses were conducted on data from cows present at both sample dates. Cows leaving the treatment lots for one or more sample periods were eliminated from the analysis.

Bacteriological Data Analysis

Equivalence between experimental and positive control teat dips was determined by constructing a one-sided confidence interval on differences between proportions of new IMI to the number of eligible quarters. When a minimum of 5 new IMI are observed in the positive control group, the lower limit confidence interval (**LLCI**) is calculated (5) by

$$\text{LLCI} = p_1 - p_2 - Z_{\alpha/2}\frac{p_1 - p_2}{\sqrt{(x_1 + x_2)/n_1 n_2}}$$

where x_1 = number new IMI in control quarters, x_2 = number new IMI in treated quarters, n_1 = number of control quarters multiplied by time unit, n_2 = number of treated quarters multiplied by time unit, $p_1 = x_1/n_1$, $p_2 = x_2/n_2$, and $Z_{\alpha/2} = 1.645$ for a 95% CI.

The LLCI statistic is inflexible in that it will detect lack of equivalence only when the treatment is less effective than the control; the LLCI will not detect differences when the treatment is more effective than the control. Equivalence by this test is indicated when the treatment and control are either equally effective or when the treatment is more effective than the control. Protocols for the application of this statistic do not allow for a simple reversal, making the treatment group the control group and vice versa. This bias inherently favors the positive control product. To account for this bias, infection data can be further tested based on the percentage of eligible quarters becoming infected in the treatment and positive control groups using a t test where t approximates Student's t test (5):

$$t = \frac{p_1 - p_2}{\sqrt{(x_1 + x_2)/n_1 n_2}}.$$

Teat dips are considered efficacious when the percentage reduction is at least 40% (5). Per-

TEAT END CONDITION SCORING

0	Teat end has been subjected to physical or chemical injury (e.g. stepped on or frostbitten) not related to treatment or the quarter is nonlactating.
1	Teat end sphincter is smooth with no evidence of irritation.
2	Teat end has a raised ring.
3	Teat end sphincter is roughened with slight cracks but no redness is present.
4	Teat end sphincter is inverted with many cracks, giving a "flowered" appearance. Teat end may have old but healing scabs.
5	Teat end is severely damaged and ulcerative with scabs or open lesions. Large or numerous warts are present that interfere with teat end function.

TEAT SKIN CONDITION SCORING

0	Teat skin has been subjected to physical injury (e.g. stepped on or frostbitten) not related to the treatment or the quarter is nonlactating.
1	Teat skin is smooth and free from scales, cracks, or chapping.
2	Teat skin shows some evidence of scaling.
3	Teat skin is chapped. Some small warts may be present.
4	Teat skin is chapped and cracked. Redness, indicating inflammation, is present. Numerous warts may be present.
5	Teat skin is severely damaged and ulcerative with scabs or open lesions. Large or numerous warts are present that interfere with teat end function.

Figure 2. University of Vermont Teat Skin and Teat End Evaluation system.

centage reduction is expressed as (5):

$$100\left(\frac{p_1 - p_2}{p_1}\right).$$

RESULTS AND DISCUSSION

Efficacy Comparison Among Primiparous Cows

Sixty-one new IMI were diagnosed among 968 quarters (Table 1): 6.8% of treatment quarters compared with 5.8% of positive control quarters. The two products were not equivalent for all new IMI. The 14.7% reduction in the positive control group was not significant by Student's *t* test. Major mastitis pathogens were diagnosed as new IMI in 25 quarters, 10 in the powder dip group and 15 in the iodine group. The products were equivalent for major mastitis pathogens. The 30% reduction in new IMI by major mastitis pathogens was not significant by Student's *t* test. Using the LLCI statistic, the powdered dip and the iodine dip did not have equivalent efficacy against coagulase-negative staphylococci (CNS). The CNS were diagnosed as the causal organism in 31 quarters (19 in treatment quarters and 12 in positive control quarters). The inequality between teat dips for IMI caused by CNS was most likely responsible for the inequality observed for all new IMI.

Environmental pathogens included streptococci other than *Streptococcus agalactiae* and coliforms and were diagnosed in 15 new IMI, 5 in the group treated with powdered dip group and 10 in the group treated with iodine. The two products were equivalent against environmental mastitis pathogens. The 45% reduction of environmental IMI in the group treated with powder was not significant. Fourteen new IMI were caused by streptococci other than *Strep. agalactiae*; 5 new IMI occurred in the treatment group and 9 in the positive controls. The products were equivalent for control of mastitis by other streptococci. The 38.9% reduction in the powder group was not significant.

The CM caused by *Staph. aureus*, coliforms, and other microbes and bacteriologically negative CM could not be compared with the LLCI statistic because <5 new IMI were diagnosed in the control group. Incidence of new IMI was not significant for any of these pathogen groups by Student's *t* test.

Distribution of New IMI in Primiparous Cows

Among quarters postdipped with the powder, the percentages of quarters diagnosed with

TABLE 1. Summary of new IMI among primiparous cows in a positive control, natural exposure evaluation of powdered teat dip.

Bacteriological status	Treatment[1]		Control[2]		LLCI[3]
	IMI	Quarter	IMI	Quarter	
	(no.)	(%)	(no.)	(%)	
Staphylococcus aureus	4	.9	1	.2	NT
Streptococci other than *Streptococcus agalactiae*	5	1.1	9	1.8	E
Coliforms	0	0	1	.2	NT
Environmental pathogens[4]	5	1.1	10	2.0	E
Other microbes[5]	1	.2	4	.8	NT
Major pathogens	10	2.1	15	3.0	E
Coagulase-negative staphylococci	19	4.1	12	2.4	NE
Clinical mastitis, bacteriologically negative	3	.6	2	.4	NT
Total new IMI	32	6.8	29	5.8	NE

[1]Powdered Teat Dip & Frost Protectant® (corn starch and comfrey extract; IBA Inc., Millbury, MA). Number of eligible quarters = 468.

[2]Bovadine® (1% iodine plus 10% glycerin; West Agro, Kansas City, MO). Number of eligible quarters = 500.

[3]LLCI = Lower limit confidence interval; E = equivalent efficacy; NE = not equivalent efficacy; NT = not tested; a minimum of 5 new IMI are required in the control group for a comparison.

[4]Streptococci other than *Strep. agalactiae* plus coliforms.

[5]Included 1 yeast and 4 *Corynebacterium bovis*.

new IMI by individual pathogen group were (Table 1) CNS, 4.1%; other streptococci, 1.1%; *Staph. aureus*, .9%; bacteriologically negative CM, .6%; other microbes, .2%; and coliforms, 0%. For the iodine-dipped group, these percentages were CNS, 2.4%; other streptococci, 1.8%; other microbes, .8%; bacteriologically negative CM, .4%; and coliforms and *Staph. aureus* each at .2% of quarters. Cumulatively, CNS and *Staph. aureus* caused 72% of all new IMI in the powder group and 45% of new IMI in the iodine group.

New IMI by CNS and contagious pathogens such as *Staph. aureus* are controlled by effective germicidal postmilking teat dips (7). These results suggested that the powdered dip had insufficient germicidal activity to control these two groups of mastitis pathogens. Postmilking teat sanitation has not successfully reduced incidence of new IMI by environmental mastitis pathogens. The powdered dip was equivalent to the positive control 1% iodine product against environmental pathogens. The 45% reduction in the powdered dip group was not statistically significant.

CM Among Primiparous Cows

Individual pathogens and bacteriologically negative CM could not be evaluated by the LLCI statistic because fewer than 5 new IMI were diagnosed in the positive control group (Table 2). No differences were observed when Student's *t* test was applied. Sixteen CM cases were diagnosed; 7 were in the treatment group, and 9 were in the positive control group. Approximately 21.9% of all new IMI were diagnosed as CM in the treatment group compared with 31% in the positive control group. The products were equivalent for all new IMI diagnosed as CM. Major pathogens were diagnosed in 2 CM quarters in the treatment group compared with 7 CM quarters in the positive control group. Twenty percent of new IMI caused by major mastitis pathogens were diagnosed as CM in the treatment group compared with 46.7% in the positive control group. Environmental pathogens were diagnosed in 1 and 6 quarters, respectively, in the treatment and positive control groups. Clinical mastitis was diagnosed in 20% of new IMI caused by environmental pathogens in the treatment group compared with 60% in the positive control group. The two products were equivalent for major and environmental pathogens. Only 10.5% of new IMI caused by CNS were diagnosed as CM in the treatment group. No CNS IMI were diagnosed as CM in the positive control group.

TABLE 2. Summary of new clinical IMI among primiparous cows in a positive control, natural exposure evaluation of powdered teat dip.

Bacteriological status	Treatment[1]		Control[2]		LLCI[3]
	IMI	Quarter	IMI	Quarter	
	(no.)	(%)	(no.)	(%)	
Staphylococcus aureus	0	0	0	0	NT
Streptococci other than *Streptococcus agalactiae*	1	.2	6	1.2	E
Coliforms	0	0	0	0	NT
Environmental pathogens[4]	1	.2	6	1.2	E
Other microbes[5]	1	.2	1	.2	NT
Major pathogens	2	.4	7	1.4	E
Coagulase-negative staphylococci	2	.4	0	0	NT
Clinical mastitis, bacteriologically negative	3	.6	2	.4	NT
Total new IMI	7	1.5	9	1.8	E

[1]Powdered Teat Dip & Frost Protectant® (corn starch and comfrey extract; IBA Inc., Millbury, MA). Number of eligible quarters = 468.

[2]Bovadine® (1% iodine plus 10% glycerin; West Agro, Kansas City, MO). Number of eligible quarters = 500.

[3]LLCI = Lower limit confidence interval; E = equivalent efficacy; NE = not equivalent efficacy; NT = not tested; a minimum of 5 new IMI are required in the control group for a comparison.

[4]Streptococci other than *Strep. agalactiae* plus coliforms.

[5]Included 1 yeast and 1 *Corynebacterium bovis*.

Efficacy Comparison Among Multiparous Cows

Among multiple lactation cows, 110 new IMI were diagnosed among 1068 quarters (Table 3); 68 were in the treatment group compared, and 42 were in the positive control group. The two products were not equivalent for all new IMI. The 67.1% reduction of all new IMI in the iodine group was significant ($P < .001$) and was a direct effect of the 93% reduction in new *Staph. aureus* IMI in the 1% iodine product. The reduction in *Staph. aureus* was significant by Student's t test ($P < .001$) but could not be evaluated using the LLCI statistic because of an insufficient number of new IMI in the positive control group. Reduction in *Staph. aureus* also resulted in inequality between the two products for IMI by major pathogens: 37 in the treatment group compared with 12 in the positive control group.

The CNS were diagnosed as the causal organism in 40 quarters (23 in treatment quarters and 17 in positive control quarters). The two products were not equivalent against CNS by the LLCI statistic. Equivalent efficacy was determined for environmental mastitis pathogens and for bacteriologically negative CM cases. Environmental mastitis pathogens were diagnosed as new IMI in 13 quarters, 5 in the powdered dip group and 8 in the iodine group. Twenty new IMI were diagnosed as bacteriologically negative cases of CM, 7 in the treatment group and 13 in the positive control group. The 48% reduction in bacteriologically negative clinical in the treatment group was not significant.

Efficacy for IMI caused by streptococci other than *Strep. agalactiae,* coliforms, and other microbes could not be compared using the LLCI statistic. Student's t test did not indicate differences between treatments for these pathogen groups.

Distribution of New IMI in Multiparous Cows

Among quarters postdipped with the powder dip, the percentage of quarters diagnosed with new IMI by individual pathogen group were *Staph. aureus* (5.7%) and CNS (4.2%); all other pathogens groups were diagnosed in <1% of quarters. For the iodine-dipped group, these percentages were CNS, 3.2%, and *Staph. aureus*, .4%; all other pathogens were <1% frequency. *Staphylococcus aureus* and CNS

TABLE 3. Summary of new IMI among multiparous cows in a positive control, natural exposure evaluation of powdered teat dip.

Bacteriological status	Treatment[1]		Control[2]		LLCI[3]
	IMI	Quarter	IMI	Quarter	
	(no.)	(%)	(no.)	(%)	
Staphylococcus aureus	31	5.7	2	.4	NT[4]
Streptococci other than *Streptococcus agalactiae*	4	.7	4	.8	NT
Coliforms	1	.2	4	.8	NT
Environmental pathogens[5]	5	.9	8	1.5	E
Other microbes[6]	1	.2	2	.4	NT
Major pathogens	37	7.0	12	2.3	NE[4]
Coagulase-negative staphylococci	24	4.4	17	3.2	NE[7]
Clinical mastitis, bacteriologically negative	7	1.3	13	2.5	E
Total new IMI	68	12.5	42	8.0	NE[4]

[1]Powdered Teat Dip & Frost Protectant® (corn starch and comfrey extract; IBA Inc., Millbury, MA). Number of eligible quarters = 544.

[2]Bovadine® (1% iodine plus 10% glycerin; West Agro, Kansas City, MO). Number of eligible quarters = 524.

[3]LLCI = Lower limit confidence interval; E = equivalent efficacy; NE = not equivalent efficacy; NT = not tested; a minimum of 5 new IMI are required in the control group for a comparison.

[4]Student's t test: $P < .05$.

[5]Streptococci other than *Strep. agalactiae* plus coliforms.

[6]Included 2 yeasts and 1 *Actinomycetes pyogennes.*

[7]Student's t test: $P > .05$.

caused 79.4% of all new IMI in the powder group and 45.2% of new IMI in the iodine group.

As was observed in the first lactation cows, new IMI by the contagious pathogen, *Staph. aureus*, and the teat skin colonizers, CNS, were not controlled by the postmilking application of powdered dip. Previous research has demonstrated the ability of conventional, germicidal postmilking teat dips to reduce significantly the colonization (2) and incidence of new IMI by these two pathogen groups (7). These results strongly suggested that the powdered dip lacks germicidal activity on teat skin. Postmilking teat sanitation with conventional germicidal products has not effectively reduced incidence of new IMI by environmental mastitis pathogens. The 40% reduction in the treatment group for IMI caused by environmental pathogens was not statistically significant. The mode of action for the powdered dip was not determined. These results indicated that the drying effect of the powdered dip may enhance control of CM caused by environmental pathogens. Bacteriologically negative CM was diagnosed in 7 quarters in the treatment group and 13 quarters in the positive control group. The 48.1% reduction in bacteriologically negative CM in the treatment group was not significant.

CM Among Multiparous Cows

The two products were not equivalent for all new clinical IMI and IMI by major pathogens (Table 4). New CM cases were diagnosed in 29 quarters in the treatment group and in 23 in the positive control group. Twenty-eight of these CM cases were caused by major mastitis pathogens, 19 in the treatment group and 9 in the positive control group. Fifteen (48.4%) of the new IMI by *Staph. aureus* were diagnosed as CM in the treatment group compared with 1 case (50%) in the positive control group. Environmental pathogens were diagnosed as CM 9 times, 3 (60%) in the treatment group and 6 (75%) in the positive control group. The two products were equivalent for environmental pathogens in quarters diagnosed as CM. Incidence of new IMI diagnosed as CM caused by streptococci other than *Strep. agalactiae*, coliforms, other microbes, and CNS could not be evaluated because of insufficient numbers in the positive control group. Fifty percent of new IMI caused by streptococci other than *Strep. agalactiae* were diagnosed as CM in the treat-

TABLE 4. Summary of new clinical IMI among multiparous cows in a positive control, natural exposure evaluation of powdered teat dip.

	Treatment[1]		Control[2]		
Bacteriological status	IMI	Quarter	IMI	Quarter	LLCI[3]
	(no.)	(%)	(no.)	(%)	
Staphylococcus aureus	15	2.8	1	.2	NT[4]
Streptococci other than *Streptococcus agalactiae*	2	.4	2	.4	NT
Coliforms	1	.2	4	.8	NT
Environmental pathogens[5]	3	.6	6	1.1	E
Other microbes[6]	1	.2	2	.4	NT
Major pathogens	19	3.5	9	1.7	NE
Coagulase negative staphylococci	3	.6	1	.2	NT
Clinical mastitis, bacteriologically negative	7	1.3	13	2.5	E
Total new IMI	29	5.3	23	4.4	NE

[1]Powdered Teat Dip & Frost Protectant® (corn starch and comfrey extract; IBA Inc., Millbury, MA). Number of eligible quarters = 544.

[2]Bovadine® (1% iodine plus 10% glycerin; West Agro, Kansas City, MO). Number of eligible quarters = 524.

[3]LLCI = Lower limit confidence interval; E = Equivalent efficacy; NE = not equivalent efficacy; NT = not tested; a minimum of 5 new IMI are required in the control group for a comparison.

[4]Student's t test: $P < .001$.

[5]Streptococci other than *Strep. agalactiae* plus coliforms.

[6]Included 2 yeasts and 1 *Actinomycetes pyogennes*.

ment and positive control groups. All new IMI caused by coliforms and other microbes were diagnosed as CM. New IMI caused by CNS were diagnosed as CM in 12.5% of cases in the treatment group compared with 5.9% in the positive control group. No differences were determined for these pathogens between treatment groups using Student's *t* test.

Teat End and Teat Skin Condition

Teat end condition scores for primiparous cows in treatment and control groups were significantly different ($P < .01$) at initiation of the trial (Table 5). Teat end condition was better in the iodine group than that in the powder group. At termination of the trial, March 1992, teat end scores of the treatment group were significantly better ($P < .001$) than those in the positive control group. Teat end condition scores decreased (improved) for the treatment groups and increased (worsened) for the positive control group during the 3 mo. The interaction of these teat end condition changes was significant by time.

Teat skin condition scores did not differ between groups at initiation of the trial in December 1991 (Table 6). Teat skin condition scores were significantly lower ($P < .01$) for the treatment group at termination of the trial. As with the teat end evaluation scores, decreases in teat skin scores in the treatment group that were concurrent with increases in scores in the positive control resulted in a significant time interaction.

Teat end condition scores in the multiparous cows for treatment and control groups were not different at initiation of the trial (Table 5). At termination of the trial, teat end scores of the treatment group were significantly better ($P < .001$) than in the positive control group. As in the heifer groups, teat end condition improved within the treatment group and worsened in the positive control group during the trial. This interaction was significant by time ($P < .001$).

Teat skin condition scores among multiparous cows were significantly different ($P < .01$) at initiation of the trial (Table 6). Teat skin scores were lower for the treatment group. Teat skin condition scores were not different at termination of the trial. In contrast to observations on teat skin condition of primiparous cows, skin condition of multiparous cows did not change in either group during the trial. Possible explanations for these results include the fact that a number of teat ends in both groups had hemorrhagic lesions commonly as-

TABLE 5. Least squares means (LSM) ANOVA of teat end condition scores of comparing treatment group versus control group and the interaction between treatment groups by time (T × G).

	LSM		
Cows and month	Treatment[1]	Control[2]	T × G[3]
Primiparous			
December	358.268[a]	293.638[b]	***
March	298.863[c]	362.837[d]	***
Multiparous			
December	271.64	298.883	***
March	244.936[c]	321.136[d]	***
All cows			
December	640.32	609.646	***
March	552.014[e]	700.171[f]	***

[a,b]Means within rows not sharing the same superscript differ ($P < .01$).

[c,d]Means within rows not sharing the same superscript differ ($P < .001$).

[e,f]Means within rows not sharing the same superscript differ ($P < .05$).

[1]Powdered Dip & Frost Protectant® (corn starch and comfrey extract; IBA, Inc., Millbury, MA). Number of eligible quarters = 544.

[2]Bovadine® (1% iodine plus 10% glycerin; West Agro, Kansas City, MO). Number of eligible quarters = 524.

[3]Significant time by group interactions existed comparing the improvement in the treatment group with the deterioration in the control group: ***$P < .001$.

TABLE 6. Least squares means (LSM) ANOVA of teat skin condition scores comparing treatment group versus control group and the interaction between groups by time (T × G).

Cows and month	LSM		
	Treatment[1]	Control[2]	T × G[3]
Primiparous			
December	327.361	329.877	***
March	305.143[a]	356.892[b]	***
Multiparous			
December	275.079[a]	296.017[b]	
March	280.567	291.444	
All cows			
December	611.676[c]	637.711[d]	*
March	593.389[a]	656.937[b]	*

[a,b]Means within rows not sharing the same superscript differ ($P < .01$).

[c,d]Means within rows not sharing the same superscript differ ($P < .05$).

[1]Powdered Teat Dip & Frost Protectant® (corn starch and comfrey extract; IBA, Inc., Millbury, MA). Number of eligible quarters = 544.

[2]Bovadine® (1% iodine plus 10% glycerin; West Agro, Kansas City, MO). Number of eligible quarters = 524.

[3]Significant time by group interactions existed comparing the improvement in the treatment group with the deterioration in the control group: *$P < .05$; ***$P < .001$.

sociated with frost bite at initiation of the trial. The procedure used for teat end and teat skin analysis excludes all scores of 0 because these are indicative of injuries unrelated to the treatment or of a nonlactating quarter. In the current analysis, only teat condition scores taken at both initiation and termination were included. Exclusion of teats that became blind during the 3 mo trial would have eliminated teat skin scores from the analysis.

When teat end condition scores were combined from primiparous and multiparous cows, no differences were apparent at initiation of the trial (Table 5). Teat end condition scores were significantly different ($P < .05$) at termination of the study. Teat end condition improved among teats dipped with the powdered dip and worsened in the iodine-dipped group.

Teat skin condition scores for all cows were significantly different ($P < .05$) at initiation of the trial (Table 6). Teat skin condition scores were significantly lower in the treatment group. At the end of the 3-mo trial, teat skin scores remained significantly different; scores were lower in the treatment group than in the control group. Teat skin condition scores increased in the iodine group and decreased in the powder group. This interaction over time was significant ($P < .05$). Because the pooled teat skin scores for all cows were lower at initiation of the trial in the powder group than in the iodine group, conclusions cannot be drawn.

CONCLUSIONS

The most notable positive efficacy result for the powdered dip was the consistent control of environmental mastitis pathogens. New IMI by streptococci other than *Strep. agalactiae* and coliforms were either equal to or less than those diagnosed in the iodine group. Additional experiments are needed to determine whether this effect is related to the drying effects of powder or to other factors. The most important negative result was observed for the multiparous cows; powdered dip did not control mastitis caused by *Staph. aureus*. The presence of less than average teat end conditions in the multiparous groups at initiation of the trial was probably a predisposition to new IMI with *Staph. aureus*. The germicidal activity of the 1% iodine product reduced the incidence of new IMI by *Staph. aureus*. Teat end conditions were normal at initiation in the primiparous groups, and sixfold fewer *Staph. aureus* IMI were diagnosed, which was an indication of the influence of teat end condi-

tion on incidence of *Staph. aureus* mastitis. The powdered teat dip was not equivalent to the positive control against CNS for either primiparous or multiparous cows. Research (5) has proved that effective germicidal teat dips significantly reduce incidence of mastitis by CNS (5), another indication of the absence of germicidal activity by the powdered teat dip.

Teat end condition scores were consistently lower in the powdered teat dip groups. In primiparous cows, teat skin condition improved for cows treated with the powdered teat dip but not for the group treated with iodine. However, no differences were determined between groups for teat skin condition in the multiparous cows. This result has not been explained.

Powdered teat dip is a cold weather alternative for postmilking teat dipping. Controlled field studies have not been conducted to compare results of powdered teat dip with those of no dipping. Long-time use on teats with damaged teat ends is not recommended at the increased risk of new IMI with the contagious pathogen, *Staph. aureus,* and the minor pathogens, CNS.

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