Evaluation of a Gel Teat Cleaning and Sanitizing Compound for Premilking Hygiene[1,2]

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ABSTRACT

A gel was developed and tested for cleaning and sanitizing cow teats for milking. Thirty lactating Holstein cows were divided into three groups of 10 each and assigned to three premilking hygiene treatments for 10 wk as follows: 1) cleaning teats with gel, allowing 30 s of contact time, and wiping residual gel off with paper towel; 2) washing teats with water and drying them with paper towel; 3) washing teats with water, drying with paper towel, predipping with .5% iodophor solution, allowing 30 s of contact time, and drying with paper towel. Individual cow composite milk and teat end swab samples were collected. The gel and predip treatments resulted in less bacterial contamination of milk and teat ends. The gel treatment had an advantage over wash and predip treatments in lower SCC and reduced mastitis. Parlor throughput was greatest for gel and wash treatments. The wash treatment group had highest SCC, bacteria in milk and on teat ends, and mastitis. Milk iodine content was low and similar for the three treatments. Daily milk production and fat and protein percentages were not affected by treatments. The gel treatment was effective, efficient, and provided good hygiene.

(Key words: gel, hygiene, mastitis, milk quality)

Abbreviation key: PIC = preliminary incubation count, SPC = standard plate count.

INTRODUCTION

Many methods of premilking udder preparation are practiced by producers. Various procedures have been studied extensively (1, 7, 9, 11, 21, 24). A common method involves washing teats by hand with water or a wash cloth and drying udder and teats with a paper towel followed by machine attachment. Recently, many producers have adopted the practice of predipping teats.

Milk quality and mammary health can be affected by premilking udder hygiene (7, 9, 10, 11). Effective udder hygiene is essential for reducing bacterial numbers on the teat skin. Improperly cleaned udders are among the sources of environmental bacteria that can contaminate milk. Premilking udder hygiene includes many factors, such as dryness and cleanliness of teats and udder (7, 9), type of drying towel used (9), type and concentration of premilking sanitizer (9, 15, 21), and sanitizer contact time with teats (9).

Perhaps the most important aspect of premilking udder hygiene is dryness of the udder at time of cluster attachment. Results of several studies (7, 11, 17, 20) have shown that water laden with bacteria can drain into teat cups after machine attachment. This contaminated water from improperly dried udder and teats gets into the milk and increases bacterial counts. Under certain conditions, these bacteria may contribute to increased mastitis.

Inflammation of the udder is usually caused by presence of a pathogen. Organisms from the environment contact the udder between and during milkings. Generally, improved hygiene

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reduced the rate of IMI (5, 10, 22, 25, 31). Poor hygiene has been associated with increased SCC and reduced milk production and quality (26). Discarded milk, health costs, tissue damage, and culled cows are among possible sources of loss associated with mastitis (26), which might be reduced with improved premilking hygiene.

Milking machine factors associated with mastitis, such as vacuum fluctuation and pulsation failure, may be exacerbated by poor premilking hygiene. Milking machines may also serve as carriers of organisms from one cow to another during milking (32), and the amount of such cross-contamination may be affected by premilking hygiene.

Premilking udder preparation methods that employ soaps, solutions, sanitizers, and other chemical agents may leave residues in milk. Although iodine is a natural component of milk, premilking udder preparation methods employing products with iodine as a disinfectant may increase milk iodine concentrations. Contamination may be by absorption through the teat skin or aspiration of residual iodine left on the teat surface by the preparation process (2, 3). Other sources of iodine in milk include dairy rations and animal medications (2, 3, 4, 8, 14, 28).

A premilking udder preparation procedure capable of minimizing surface water and reducing numbers of microorganisms on teats without leaving residues in milk will result in improved milk quality and udder health. The objective of this study was to compare the efficacy of using a gel with teat cleaners and sanitizers to prepare teats for milking with the efficacy of washing and drying teats using plain water with or without a .5% iodophor predip.

MATERIALS AND METHODS

Origin and Description of Data

Cows and facilities at the Louisiana State University Dairy Research Farm, Baton Rouge, were used for this study. Data collected included a.m. and p.m. milk weights, composite milk fat and protein percentages, SCC, premilking udder preparation time, parlor throughput, bacterial counts in weigh jar milk and from teat swab samples, iodine content in milk, clinical mastitis incidence, incidence of new IMI, and identification of mastitis pathogens present in quarter milk samples before, during, and after the trial.

Cows and Farm Facilities

All quarters of all cows were determined to be free of IMI prior to beginning the trial based upon two consecutive, aseptically collected quarter foremilk samples being free of pathogens. Methods employed for identification of pathogens are described in the Laboratory Analyses section. Only cows that met these criteria were selected from the herd to be used in the experiment. Milk samples from quarters of cows that experienced clinical mastitis during the trial were analyzed for identification of pathogens. Diagnosis of clinical mastitis was determined by the herdsperson. Samples were collected on all new clinical cases before antibiotic treatment was administered.

All quarters were sampled on 2 consecutive d at the end of the trial. If one of the quarter foremilk samples cultured positive in the consecutive samples, another sample was taken for confirmation. Any quarters that became clinical during the trial or cultured positive twice at the end were classified as new IMI.

Thirty Holstein cows without any IMI were used in the study. These 30 cows were grouped according to age, lactation number, and milk production; cows within groups were randomly assigned to three treatments. Pretrial data characterizing treatment groups are presented in Table 1. Data collection was over a 10-wk period.

Cows on the trial were managed together. Concrete floors were scraped daily in the loafing barn that housed the cows. Cows were milked twice a day starting at 0300 and 1430 h. The milking parlor was a double-four, side-opening parlor with eight stalls and a weigh jar at each stall. Machines were removed by hand. Individual cow milk production was recorded at each milking. Other management factors were uniform for all cows on the study.

Experimental Treatments

Three experimental treatments were used. The first employed a gel with teat cleaning and

TABLE 1. Pretrial means for animals assigned by treatment.

Variable	Treatment[1]		
	Gel	Predip	Wash
Number of cows	10	10	10
Days in milk	132.0	130.4	130.9
Daily milk production, kg	23.3	23.5	23.8
Lactation number	1.6	1.7	1.5
Age, mo	40.1	40.5	39.7
SCC, $\log_{10}$	4.89	4.99	4.91
Fat percentage	3.14	2.51	2.99
Protein percentage	2.48	2.54	2.58

[1]Gel treatment was massaging teats with gel and allowing 30 s of contact time, drying each teat with paper towels, and attaching the milking machine. Wash treatment was washing teats with hand and water without sanitizer using a hose with spray nozzle, drying teats with paper towels, and attaching the milking machine. Predip treatment was the same as wash except predipping with a .5% iodophor teat dip with 30 s of contact time before final drying was added.

sanitizing agents developed by the authors. Premilking preparation included examining foremilk for abnormalities; massaging teats with gel, allowing 30 s of contact time; drying each teat with a single-use paper towel; and attaching the milking machine.

The second treatment was cleaning teats using water from a hose with spray nozzle and drying teats with paper towels. Premilking preparation included examining foremilk for abnormalities, washing teats with hand and water without sanitizer using a hose with spray nozzle, drying each teat with single-use paper towels, and attaching the milking machine.

The third treatment was the same as the second, except that predipping with a .5% iodophor solution was added. Premilking preparation included examining foremilk for abnormalities, washing teats with hand and water from a water hose with spray nozzle, drying each teat with single-use paper towels, dipping each teat in a .5% iodophor predip solution allowing 30 s of contact time, wiping each teat dry with single-use paper towels, and attaching the milking machine.

Immediately following machine removal, all teats of all cows were dipped in a commercial teat dip containing 1% iodophor (Teat-Kote™, Babson Bros. Co., Naperville, IL).

Gel with Teat Cleaning and Sanitizing Agents

The experimental gel was a water-based mixture containing .5% iodophor as the active ingredient. It also contained a detergent, glycerin, and an aqueous gelling agent that is generally recognized as safe for human consumption.

The gel was mixed in a 3.78-L commercial Waring blender (New Hartford, CT) in 2-L batches. The gel was poured into 473-ml plastic squeeze bottles provided by Paxon Polymer Co. (Baton Rouge, LA) and equipped with locking spout closures provided by Seaquist Closures (Pittway Corporation, Crystal Lake, IL). Gel was dispensed directly from these plastic containers into the milkers' hands, and the caps were closed between milkings.

The experimental gel had a pH of 5.25 and a freezing point of –4°C. Viscosity and shear analyses of the gel showed an apparent viscosity between 12×10^3 and 6×10^4 cP at 25°C under normal shear stress. This range depended upon how fast the gel was mixed, moved, or pumped because both the apparent viscosity and rate of shear varied with changing shear stress. Other properties of the gel obtained from these analyses were a flow behavior index of .2605 and average fluid consistency index of 556.14 dyn-s/cm^2.

Milk and Teat End Swab Samples

Individual cow composite milk and teat end swab samples were collected once a week. Aseptic collection procedures using sterile disposable syringes, plastic tubes, and plastic vials were used to obtain milk samples from weigh jars at the morning milking. Cows on the same treatment were milked together to

prevent contamination of weigh jars between treatments. Before each sample was drawn, milk was agitated by allowing air to enter at the bottom of the weigh jar for 3 s, and the weigh jar spout was disinfected with a cotton swab soaked in 95% ethanol. Samples were immediately placed on ice and transported to the laboratory for microbiological analyses. Additional samples were collected at the same time from each weigh jar to determine milk fat and protein percentages, SCC, and iodine.

Teat end swabs were collected by making three complete circular motions over the surface of the teat end. Only the right front teat of each cow was swabbed. Swabs were placed in sterile test tubes containing 5 ml of rinse solution and transported on ice to the laboratory. Rinse solution was a mixture of .85% NaCl, .1% proteose-peptone, and .2% sodium thiosulfate.

Aseptic quarter foremilk samples were used to determine presence of pathogens and IMI status. Samples were taken by washing the teat thoroughly, drying the teat with paper towels, sanitizing the teat end by scrubbing vigorously with a swab saturated with 70% isopropyl alcohol, and directing foremilk streams into sterile sample vials tilted to avoid contamination. Samples were stored on ice during collection and for transporting to the laboratory. Samples were analyzed fresh.

Laboratory Analyses

Bacterial Counts. One-milliliter samples were plated on 3M Petrifilm™ (St. Paul, MN) in duplicates of two dilutions to obtain a bacterial count comparable with the standard plate count (SPC) (13, 29). The SPC method is commonly used to estimate contamination or total microbial population of raw milk (6, 28). A preliminary incubation (PIC) count was also obtained from each sample in a method similar to SPC (19). Preliminary incubation count was reported by Johns in 1960 (19) and is based upon the theory that the normal bacterial flora of the udder do not grow well at 13°C, whereas many external bacterial contaminants do. A 10-ml aliquot of each milk sample was transferred into a sterile vial and incubated at 12.8 ± 1°C for 18 h ± 15 min.

Petrifilms™ were prepared and incubated according to the directions for use provided by the 3M Company (Medical Surgical Division, 3M Health Care, St. Paul, MN). The temperature of incubation was 32 ± 1°C for 48 ± 3 h (27). Bacterial colonies were also counted according to standard methods.

Milk Composition. Duplicate samples of milk were analyzed for iodine content using an Orion® model 901 Microprocessor Ionanalyzer (Orion® Research Inc., Laboratory Products Group, Boston, MA). Iodine concentration in each sample was determined according to manufacturer's recommendations (23). Milk fat percentage, protein percentage, and SCC were also determined from duplicate composite samples of raw milk by the Louisiana DHI Laboratory. Somatic cell counts were determined using a Fossomatic model 215 automatic cell counter (Foss Food Technology Inc, Eden Prairie, MN). Milk fat and protein percentages were determined using a Foss Electric Milko Scan model 605 (Foss Food Technology, Inc.).

Mastitis Diagnosis and Pathogen Identification. Aseptically collected foremilk samples were agitated, and .1 ml of the sample was streaked onto a tryptose blood agar plate (Difco, Detroit, MI) and a MacConkey agar plate (Difco). Plates were incubated at 35°C for 24 to 48 h, and colonies were tentatively identified by utilizing Gram stain, colony morphology, hemolytic characteristics, and catalase test. Gram-negative rods were identified using conventional biochemicals and API 20E (API, Division of Sherwood Products, Plainview, NY). Gram-positive rods were identified using the acid-fast staining method. Gram-positive cocci were identified using catalase and hydrogen peroxide. Staphylococcal organisms were identified using the Rapid Mastitis Test™ (Immucell, Portland, ME) and Staph Ident™ (API, Plainview, NY). Identification of streptococcal pathogens was determined using the Rapid Mastitis Test™ (Immucell, Portland, ME), carbohydrate fermentation (phenol red), bile esculin, and CAMP reaction.

Udder Preparation Time

Time to prepare the cow's udder for milking was defined as the period between her entry into the stall and complete cluster attachment. This measurement was taken weekly during afternoon milking for all treatments.

TABLE 2. Least squares means for milk production, fat and protein percentages, $\log_{10}$ of SCC, and milk iodine content of composite milk by treatment.

Variable	Treatment[1]		
	Gel	Predip	Wash
Milk production, kg	22.63	22.32	22.81
Fat percentage	3.14	3.16	2.84
Protein percentage	2.88	2.84	3.16
Log_{10} SCC	5.05[a]	5.24[b]	5.18[b]
Iodine, μg/L	11.00[a]	10.10[a]	9.20[b]

[a,b]Means with different superscript letters on the same line differ ($P < .05$).

[1]Gel treatment was massaging teats with gel and allowing 30 s of contact time, drying each teat with paper towels, and attaching the milking machine. Wash treatment was washing teats with hand and water without sanitizer using a hose with spray nozzle, drying teats with paper towels, and attaching the milking machine. Predip treatment was the same as wash except predipping with a .5% iodophor teat dip with 30 s of contact time before final drying was added.

Parlor throughput data was collected to determine the average number of cows milked per hour for each treatment. This could not be done during the main trial because of simultaneous execution of all three procedures at each milking. After the main trial, the entire herd of 120 cows was divided into three groups of equal numbers and average milk production. These grouping criteria were used to reduce variation among groups for machine-on time. Timing of each group started with the parlor entrance of the first cow and ended with complete removal of the last cluster. Each group was measured twice a day for 2 d. Premilking preparation treatment was then changed and measured again following a 2-d acclimation period to allow milkers to get used to the new procedure. Fresh and sick cows were excluded. Time and number of cows milked were averaged for each treatment, and number of cows milked per hour was determined.

Statistical Analyses

All bacterial counts and SCC observations were $\log_{10}$-transformed and analyzed. Variables were analyzed using least squares techniques and the general linear models procedure of SAS (30). The experimental design used was a split-plot in time adapted from Gill and Hafs (12).

The statistical model was

$$Y_{ijkl} = \mu + \alpha_i + \beta_j(\alpha_i) + \delta_k + \alpha\delta_{ik} + \varepsilon_{ijkl}$$

where

Y_{ijkl} = an observation of a dependent variable,
μ = effect common to all observations,
α_i = effect from treatment i,
$\beta_j(\alpha_i)$ = effect from cow j in treatment i,
δ_k = effect from week k,
$\alpha\delta_{ik}$ = interaction effect between treatment i and week k, and
ε_{ijkl} = error.

Cow was considered a random effect, and all other effects except error were considered fixed. Calculation of least squares means and test of differences between selected means was done using the general linear models procedure of SAS (30).

Differences in percentage of quarters becoming infected between treatment groups were tested using a t test that approximated a Student's t statistic and reduction rates calculated according to methods of Hogan et al. (16) as recommended by the National Mastitis Council.

RESULTS AND DISCUSSION

Milk Production and Composition

Least squares means for milk production, protein percentage, fat percentage, $\log_{10}$ SCC, and iodine content are presented in Table 2.

TABLE 3. Least squares means of $\log_{10}$ of standard plate count (SPC) and preliminary incubation count (PIC) in milk and on teat end swabs by treatment.

	Treatment[1]		
Variable	Gel	Predip	Wash
$\log_{10}$ milk SPC	3.07[a]	3.05[a]	3.40[b]
$\log_{10}$ milk PIC	3.31[a]	3.40[a]	3.66[b]
$\log_{10}$ teat swab	4.02[a]	3.97[a]	4.46[b]

[a,b]Means with different superscript letters on the same line differ ($P < .05$).

[1]Gel treatment was massaging teats with gel, allowing 30 s of contact time, drying each teat with paper towels, and attaching the milking machine. Wash treatment was washing teats with hand and water without sanitizer using a hose with spray nozzle, drying teats with paper towels, and attaching the milking machine. Predip treatment was the same as wash except predipping with a .5% iodophor teat dip with 30 s of contact time before final drying was added.

Milk production, fat percentage, and protein percentage were not affected by treatments. Somatic cell counts were lower in gel than in predip or wash treatments. Iodine content of milk was significantly lower in the wash treatment group, but concentrations were very low in all three treatments and within normal ranges. The overall difference observed between means was only 1.8 ppb.

Low concentrations of iodine have been reported by Conrad and Hemken (2) and Galton et al. (11), although these concentrations were not as low as in this study. Jenness and Patton (18) cited a normal range of milk iodine concentrations between 10 and 80 μg/L for animals not consuming supplemental iodine in the ration. Iodine concentrations observed in this study fell within that range.

The ration fed during the trial consisted of corn silage, a 21% commercial dairy pellet, and whole cottonseed. There was no supplemental iodine in the ration. Teat skin of cows in the gel and predip treatments was exposed to iodine more than that of cows in the wash group because cows in the wash group had iodine on their teats only as a postdip.

Bacterial Counts

The $\log_{10}$ milk SPC, PIC, and teat end swab SPC least squares means are presented in Table 3. Use of sanitizing agents to prepare the udder for milking significantly ($P < .05$) lowered numbers of bacteria in raw milk and on teat ends. The gel and predip treatments had similar raw milk bacterial counts (Table 3), and both were lower than in the wash treatment. These results agree with Galton et al. (9) and Adkinson et al. (1). Bacterial counts from teat end swabs followed a pattern similar to counts from raw milk.

Premilking Udder Preparation Time and Parlor Throughput

Least squares means in Table 4 indicate that the wash treatment had the shortest preparation

TABLE 4. Least squares means for premilking preparation time and parlor throughput by treatment.

	Treatment[1]		
Variable	Gel	Predip	Wash
Preparation time, s	95[a]	105[b]	66[c]
Throughput, cows/h	55[a]	43[b]	51[a]

[a,b,c]Means with different superscript letters on the same line differ ($P < .05$).

[1]Gel treatment was massaging teats with gel and allowing 30 s of contact time, drying each teat with paper towels, and attaching the milking machine. Wash treatment was washing teats with hand and water without sanitizer using a hose with spray nozzle, drying teats with paper towels, and attaching the milking machine. Predip treatment was the same as wash except predipping with a .5% iodophor teat dip with 30 s of contact time before final drying was added.

TABLE 5. Mastitis data by treatment.

Variable	Treatment[1]		
	Gel	Predip	Wash
Quarters available	36	40	40
Quarters clinical	0	5	9
Quarters subclinical	2	1	2
Total new IMI	2	6	11
Infection rate, %	5.5[a]	15.0[b]	27.5[c]
Reduction over wash, %	79.8	45.0	
Reduction over predip, %	63.0		

[a,b,c]Means with different superscript letters on the same line differ ($P < .05$).

[1]Gel treatment was massaging teats with gel and allowing 30 s of contact time, drying each teat with paper towels, and attaching the milking machine. Wash treatment was washing teats with hand and water without sanitizer using a hose with spray nozzle, drying teats with paper towels, and attaching the milking machine. Predip treatment was the same as wash except predipping with a .5% iodophor teat dip with 30 s of contact time before final drying was added.

time, followed by gel, and then predip because gel and predip required an additional 30-s contact time not included in the wash treatment. The gel treatment reduced teat end and raw milk bacteria similarly, but gel treatment required less preparation time. The gel treatment had a shorter preparation time than predip because cow's teats in predip were washed and dried before predipping, but teats prepared with gel were not. The wash treatment had a significantly shorter preparation time than either gel or predip, but wash had the highest bacterial count in milk and on teat ends, and, consequently, poor milk quality and udder health would likely result.

More cows per hour were milked in the gel (n = 55) and wash (n = 51) treatments than predip (n = 43). The difference between gel and wash treatments, although not statistically significant, represents a 7% advantage. Lower bacterial counts were obtained by the gel treatment. Parlor efficiency lost by introducing a predip step could be regained by gel cleaning without sacrificing good hygiene.

Mastitis

Least squares analysis of SCC data (Table 2) indicated lower SCC for the gel than for either predip or wash treatments. Milk samples from cows with clinical mastitis were not included. The wash and predip treatments had similar SCC means. The gel treatment did not require water. This may make the gel a more effective method of premilking udder preparation under management conditions that require cleaning cows udders with water before predipping because bacterial contamination from wash water has been reported (7, 11, 17, 24) to cause IMI and increase SCC. Milk quality as determined by flavor, shelf-life, and production of manufactured products also deteriorates with increasing SCC. Low SCC is an indication of good udder health and should be an objective of a premilking udder hygiene program.

Pathogens isolated in a herd culture before starting the study included *Staphylococcus aureus, Staphylococcus epidermidis, Staphylococcus saprophyticus,* and *Streptococcus dysgalactiae. Staphylococcus aureus* and *S. dysgalactiae* were isolated in two of the clinical mastitis cases that occurred in the wash treatment during the study. One case of clinical mastitis caused by *Escherichia coli* was recorded in the predip treatment. No clinical cases were observed in the gel treatment during the study.

Mastitis results are presented in Table 5. New IMI were significantly reduced by the gel compared with the wash and predip treatments (79 and 63%), respectively. New IMI were reduced 45% when predip was compared with wash. The percentage of reduction in new clinical mastitis cases between the gel and the other two treatments was 100%. New clinical mastitis cases were reduced 54.6% by predip when compared with incidence in the wash treatment group.

The wash treatment resulted in more mastitis cases than the gel and predip treatments,

thus emphasizing the effect of good premilking hygiene on udder health. In comparison with the predip procedure, gel would be a preferable method of premilking udder preparation under conditions that require washing prior to predipping. The procedure cleans and sanitizes teats without leaving contaminated water to drain into teat cups. Premilking hygiene was achieved using the gel procedure and resulted in less mastitis, better milk quality, and good parlor efficiency.

The gel did not irritate skin or stain milkers' hands. Visual examination of teat skin during and after the trial did not reveal any abnormalities.

CONCLUSIONS

Use of the gel and predip procedures decreased bacterial count on teat ends and in harvested milk over counts with the wash treatment. The gel procedure did not include the use of water and maintained lower SCC than two procedures that did: predip and wash. Mastitis was lower in gel than in predip and wash groups. Both gel and predip resulted in slightly higher iodine concentrations in milk, but all treatment concentrations were normal and acceptable.

There were no observed detrimental effects of the treatments on production, fat, or protein percentage of harvested milk. The gel treatment was more efficient in number of cows milked per hour than the predip treatment. The wash procedure did not provide adequate hygiene.

An effective milking management program must include adequate udder hygiene. The new gel exhibited several advantages over methods currently in use. Its full potential as an alternative premilking udder preparation should be further explored.

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