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Short communication: Dipping efficiency and teat dip residues in milk using an automatic dipping system

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ABSTRACT

Prototypes of the automatic-dipping system Apollo were tested with the IQ milking cluster (GEA Farm Technologies GmbH, Bönen, Germany) to determine the teat-dip residues in the milk and the dipping performance (number of dipped teats) of the system compared with manual (hand) dipping. A laboratory trial and a field trial at a dairy farm were performed to determine the iodine level in the milk when an iodine-based teat dip was used. In the laboratory trial, the mean difference between the 53 paired samples (sampling upstream and downstream of the cluster) was 18.9 ± 3.18 μg of iodine/kg. A field trial at a 300-cow commercial dairy farm consisted of taking 2 sets of individual cow milk samples 6 wk apart. Three weeks before the second test day, the iodine-based teat dip was replaced by an iodine-free teat dip. The mean difference between the 2 sets of 55 samples was 25.1 ± 5.22 μg/kg. Compared with manually applying an iodine-based teat dip, the increase in the iodine content resulting from the use of the tested cluster with automatic dipping was very low and would not be an issue of food safety. The dipping performance tests were completed on the same 300-cow commercial dairy farm as the field iodine level trial was performed. In total, 4,541 teats from 307 cows were observed on 4 consecutive days, showing a 91.6 ± 1.3% success rate.
Key words: dairy cow, milking, teat dipping, iodine

Short Communication

One of the most effective mastitis prevention techniques is applying an appropriately formulated disinfection solution to the cow's teat directly after machine milking. The teat is moist with nutrient-rich milk and the teat canal remains open right after milking, exposing the quarter to infection. The moist and vulnerable teats are subsequently exposed to bacteria-laden insects, bedding, manure, and so on throughout the day. Teat disinfection solution consistently applied directly after milking will kill contagious organisms on the skin surface along with covering the open teat canal with a germ-killing barrier (Boddie et al., 2004). In addition to the germ-killing components, the teat disinfection solution is formulated with skin-conditioning agents to reduce chapping and to help keep the teat skin smooth and supple. By reducing the cracks and crevices in the teat skin, fewer places exist for contagious organisms to colonize.

To reduce the need for labor and provide consistency, mundane and repetitive tasks, such as applying teat dip, are being automated. Several advantages exist of applying the teat dip at the end of the milking process directly through the liner dome. The teat is treated while it is under vacuum, stretched out, and flaccid, allowing the dip to penetrate deeply (Galton, 2004). The teat is also protected before the liner is removed, exposing the teat to the environment. Teat dip is applied in a controlled manner, reducing waste and reducing the worker exposure to automatized teat dip. Automated in-cluster teat dip applications have shown to be effective in reducing new IMI and improving herd health (Galton, 2004; Olde Riekerink et al., 2012). However, because the dip solution is being applied through the cluster, adequate protections need to be used to ensure milk safety. Therefore, GEA Farm Technologies GmbH (Bönen, Germany) has recently developed an in-liner dipping system (The Apollo MilkSystem) and the objective of this study was to assess the dipping performance and the system's ability to ensure milk safety.

In trial 1, a laboratory test was done to ascertain dipping residues in the milk. Just before the cluster was removed at the end of milking, the automated dipping system closed the long milk tube and automatically applied teat dip to the inside of the teat-liner head with an iodine-containing dipping solution. After the rinsing cycle was complete, a chance existed that some residual teat dip could be flushed out in a subsequent milking session. All trials were performed with a 0.5% iodine-based dip. The iodine content of the milk was

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analyzed in a certified laboratory using gas chromatography, which has an accuracy of 8.51 μg/kg and a repeatability of 24 μg/kg.

Tests for teat-dip residues after cleaning and disinfection of the cluster were conducted at the Leibniz-Institute for Agricultural Engineering Potsdam-Bornim (ATB, Potsdam, Germany) testing environment. The testing environment was equipped with the same version Apollo IQ dipping cluster as the milking parlor tested in trials 2 and 3. Fresh chilled raw milk from the bulk milk tank of a neighboring dairy farm was heated to 25°C. Using a milking vacuum system, the heated milk was passed via 4 flow controllers (total flow: 2.5–3 L/min) to 4 artificial teats (method ISO/DIN 6690; ISO/DIN, 2007), to which the IQ cluster with automatic dipping was attached. Samples were taken from the milk flow upstream and downstream of the cluster. Sampling was done using a sampler (Tru-Test Ltd., Manukau, New Zealand). Ten milliliters of dipping solution was used for each dipping. During the subsequent automatic rinsing and disinfection of the cluster, the artificial teats were cleaned by hand with paper towels and the samplers were prepared for the next run.

A total of 53 sample pairs were taken in this way. The frozen milk samples were then sent to the above-mentioned laboratory to determine the iodine content. The differences in the iodine content found upstream and downstream of the cluster were checked for a positive distinction from zero (1-sided paired *t*-test), using the TTEST procedure in SAS (version 9.2; SAS Institute Inc., Cary, NC).

Trial 2 was designed to determine the iodine level of the automated dipping system using an iodine-based teat dip (the same 0.5% iodine-based dip as also used in the other trials) and comparing it with the same system using a non-iodine-based teat dip on a dairy farm. Two sample sets were taken, one using iodine-based teat dip and the second set, 6 wk later, using a non-iodine-based teat dip. The iodine-based dipping solution was used with an amount of 12 mL per dipping. About 3 wk before taking the second set of samples, the iodine-based teat dip was replaced by a non-iodine-based teat dip. Of the 36 stalls in the rotary parlor, 18 were selected at random and equipped with samplers (Tru-Test Ltd.). Fifteen of these 18 stalls were the same for both sample sets. On the second test day, milk samplers could not be mounted at 3 stalls because of mechanical problems and were placed at 3 different stalls. Milk samples were taken on both test days after the start of milking until 55 samples with a sufficient quantity of milk had been collected for the laboratory analysis (corresponding to ≥13 kg of milk per milking). These 110 samples came from 93 cows randomly milked in the selected stalls. A mixed linear model was selected to ascertain the difference in the iodine content of the milk for the 2 dipping solutions:

$$y_{ijk} = \mu + DS_i + S_j + C_k + \varepsilon_{ijk},$$

where y_{ijk} = monitored milk iodine content, μ = general mean milk iodine content, DS_i = fixed effect of the ith dip (i = 1 or 2), S_j = fixed effect of the jth stall (j = 1, . . . , 21), C_k = random effect of the kth cow (k = 1, . . . , 93), and ε_{ijk} = independent residual with normal distribution. The model was implemented with the MIXED procedure in SAS (version 9.2; SAS Institute Inc.).

Four milking sessions were observed at the same milking parlor as in trial 2 to determine if the teats were automatically dipped after removal of the cluster unit with automatic dipping function. A teat was considered dipped only if a drop of dip had formed at the end of the milk duct. Each udder was treated with 12 mL of dip. The lower 95% confidence limit for mean dipping success was estimated for a half-width of 2 standard deviations. For the necessary single-sided *t*-test, a minimum of 4 milking sessions had to be evaluated at a level of significance of $\alpha = 0.05$ and an intended power of 90%.

Quarters were classified as follows: quarter with drop formation (QDr), quarter without drop formation (QwoDr), and quarter without dipping (QwoD). The total of these quarters yielded the maximum number of quarters that needed to be dipped (Qmax). Accordingly, the dipping success (DS) was calculated as follows:

$$DS = [1 - (QwoDr + QwoD)/Qmax] \times 100.$$

The laboratory test was conducted to determine the dipping residues after cleaning and disinfection of the cluster (Table 1). The iodine content of the samples taken downstream of the cluster was, therefore, signifi-

Table 1. Iodine content in milk up- and downstream of the cluster

Sample	n	Mean iodine content (μg/kg)	SD (μg/kg)	SE (μg/kg)
Upstream	53	61.94	16.56	
Downstream	53	80.89	22.35	
Difference ($P < 0.0001$)		18.94		3.18