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Letter to the Editor

"Effectiveness of Electrolyzed Acidic Water in Killing *Escherichia coli* O157:H7, *Salmonella* Enteritidis, and *Listeria monocytogenes* on the Surfaces of Tomatoes," A Comment on: *J. Food Prot.* 66(4):542–548 (2003)

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This article is generally well written and demonstrates the benefits of using electrolyzed water for controlling pathogens. However, it also includes a serious systematic error in Tables 2, 3, and 4. The authors have added the logs of the population values without first taking the antilog to calculate the residual microbial populations. This procedure overstates the residual microbial populations in the control, water, and 200-ppm chlorine cases in all three tables. This improper calculation is responsible for the negative log reductions reported for the controls.

The authors compound this error and dramatically overstate the comparative benefits of using electrolyzed water. The authors report <1 log CFU/tomato for each of the electrolyzed water samples and assert in the footnote that no colonies were detected. If the authors had used the same, albeit erroneous, calculation strategy, they would have reported a >4.63-log reduction in the first case in Table 2. Similar results would have been reported for the other five electrolyzed water cases. One is left to question whether the <1 values reported reflect a detection limit of 10 CFU/tomato or the improper reporting of <1 CFU/tomato, which would be <0 log CFU/tomato. In either case, achieving this low of a detection limit in 200 ml of rinse water requires some form of concentration as used for water analysis. Such a filtration was not reported. We know with certainty that the tomatoes were not organism free because organisms were detected with the enrichment procedure.

The choice to use 200 ppm chlorine at pH 9.3 does not reflect practice in the produce industry. The fresh produce industry is well aware that hypochlorous acid (HOCl) is much more effective than hypochlorite (OCl^-) as an antimicrobial agent and therefore adjusts pH with acid addition. A better comparison would have been to adjust the pH of the chlorine solution to about pH 6 where the chlorine is fully protonated as hypochlorous acid and therefore more effective. Furthermore, the use of the electrolyzed water at pH 2.7 will push the equilibrium beyond 100% hypochlorous acid and will include a significant fraction that is diatomic chlorine (Cl_2) in solution. At low pH values, the fraction of the chlorine that is diatomic chlorine in solution and the fraction that is hypochlorous acid are linked by the reversible reaction

$$Cl_2 + H_2O \leftrightarrow HOCl + H^+ + Cl^-$$

whose equilibrium constant is 3×10^{-5}. As pH decreases and/or chloride concentration increases, the fraction of hypochlorous acid will decrease, which can be expected to reduce the antimicrobial efficacy. One is left to question why the authors did not use a pH of at least 5 for the treatment with electrolyzed water.

And finally, the authors' analysis of the data attributes all of the reduction of the microbial population to the electrolyzed water. In the control samples, only about 10% of the organisms were recovered giving a 1-log cycle reduction to the control. Washing with just water achieved another 2-log cycle reduction. Given these observations, claiming that the electrolyzed water yielded a 7-log reduction seems an exaggeration. With these corrections, the effectiveness of the electrolyzed water would be more consistent with those observed by other researchers.

Response

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Comments on our article are much appreciated. In Tables 2, 3, and 4, log values of microbial populations were added without first taking the antilog to calculate the reduction values, and thus the residual microbial populations in control, water, and 200-ppm chlorine water were overstated. We have recalculated values for these tables using antilog values. The recalculated values are presented in the "Erratum" published in this issue. No error occurred for the electrolyzed oxidizing water data, because no colonies were recovered from rinse water, peptone wash, and skin-pulp homogenates.

Comparing a pH value of at least 5 for the treatment with electrolyzed water would have been better, but some researchers had already done that work *(1)*. However, there are some small-scale fresh produce industries that are using 200 ppm chlorine water and who are not caring about the pH. In consideration of this fact, we designed the experiments using 200 ppm chlorine water without changing the pH. I do appreciate your suggestion and will be keeping it in mind for future experiments.

Finally, the data that appeared in the manuscript were the results of the experiments done in our laboratory.

REFERENCE

1. Nakagawara, S., T. Goto, M. Nara, Y. Ozawa, K. Hotta, and Y. Arata. 1998. Spectroscopic characterizations and the pH dependence of bacterial activity of the aqueous chlorine solution. *Anal. Sci.* 14:691–698.