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Comparison of a continuous flow dipper well and a reduced water dipper well combined with ultraviolet radiation for control of microbial contamination

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ABSTRACT

Continuous flow (CF) dipper wells, or small countertop sinks, are used in the foodservice industry for rinsing utensils such as stirring spoons and dishers. In addition, these dipper wells are designed as continuous flow not only to rinse and clean but to also control for the buildup of microorganisms. Here, we evaluate a reduced water (RW) dipper well – with and without ultraviolet subtype C (UV-C) disinfection – for control and inactivation of *Escherichia coli* present on a stainless steel utensil. Overall, the RW dipper well (with and without UV-C) performed significantly better than the CF dipper well for removal of *E. coli* in 10% skim milk medium at various exposure and rinse times. More specifically, at 5, 10, and 30 s, the RW dipper well without UV-C achieved 1.04, 1.72, and 2.03 greater $\log_{10}$ (CFU/ml) reduction in *E. coli* compared to the CF dipper well at the same treatment times, respectively. When combined with UV-C, the RW dipper well increased reduction of *E. coli* by 0.36–1.68 $\log_{10}$ (CFU/ml) over prolonged use (i.e. 2 h continuous use). Moreover, the RW dipper well combined with UV-C may provide a preventative step to reduce the growth and/or persistence of bacteria on the utensil as well as the dipper well reservoir, especially for *E. coli* in 10% skim milk medium. To our knowledge this is the first study to evaluate the efficacy of dipper wells – both RW and CF systems – in the removal of *E. coli* on a stainless steel utensil.

1. Introduction

Within certain sectors of the foodservice industry (e.g., select restaurants, coffee shops, and ice cream parlors), dipper wells, or small countertop sinks, are used to rinse utensils between uses. A conventional dipper well usually contains a single spigot and a valve that controls the flow of water into the receiving well—basically a perpetual-flow sink that simultaneously fills and drains water (Brean, 2009). The concept of a dipper well was first introduced in 1951 by Lerner who reported on the unhygienic aspects of storing ice scream scoops in jars of water between service, thus potentially allowing for the growth of microorganisms during periods of warm weather. This study indicated that replacement of water at least every 20 min was necessary to eliminate potential contaminants (Lerner, 1951). Typically, the dipper well is turned on to full flow and never turned off during service hours to allow for a constant exchange of water in the well (USEPA, 2012). These types of constantly flowing dipper wells are standard equipment in the foodservice industry to comply with the U.S. Food and Drug Administration (FDA) Food Code regarding storage of in-use utensils. Briefly, Section 3-304.12 D of the 2013 Food Code states that storage of utensils in-use must be placed in running water of sufficient velocity to flush particulates down the drain, especially if used with moist food such as ice cream or mashed potatoes (FDA, 2013). The assumption is that the constant flow of water serves 1) to prevent the accumulation of microorganisms and 2) to aid in maintaining the cleanliness of the well (FDA, 2013; USEPA, 2012). However, issues have arisen due to the amount of water (e.g., flow rate between 2 and 4 L/minute) used by continuous flow (CF) dipper wells especially in areas impacted by water scarcity and drought (Brown & Matlock, 2011; USEPA, 2012). For instance, Dupalo and colleagues estimated 2453 dipper wells in use in Southern Nevada alone with each of these dipper wells using 1,103,848 L of water per day – approximately 402.8 million L/yr (Brean, 2009). Based on these data, there is a clear need to provide the foodservice industry with an alternative product that is more

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sustainable with respect to water use, but that also meets expectations related to local food codes for storage of in-use utensils as described in the U.S. FDA Food Code (FDA, 2013).

Currently, there are very few alternatives to CF dipper wells. These alternatives range from a reduced water (RW) dipper well option to utilization of undercounter dishwashers to foodservice policy changes (e.g., one time use of utensils followed by washing). However, options requiring one time use of utensils are often impractical to implement in a high volume foodservice establishment. Here, this study aims to evaluate and compare a RW dipper well and CF dipper well. First, a RW dipper well was evaluated for its ability to remove and inactivate *Escherichia coli* on stainless steel utensils by treatment with either water only or water combined with ultraviolet radiation subtype C (UV-C). Ultraviolet (UV) radiation can be subdivided into three regions (Giese, 1964)—short wave (UV-C), medium wave (UV-B), and long wave (UV-A)—with UV-C (wavelengths from 200 to 280 nm) having germicidal effects on microorganisms (Bintsis, Litopoulu-Tzanetaki, & Robinson, 2000). Second, microbial growth over time was investigated during continuous use (i.e., 2 h period) of the RW dipper well. Finally, the efficacy of the CF and RW dipper well in removal and/or inactivation of *E. coli* were compared at three different treatment times as well as over a 2-h period of continuous use.

2. Materials and methods

For this study, a RW and a CF dipper well were evaluated. The RW dipper well (Rinsewell™ Elongated, Recycled Hydro Solutions, Rogers, AR) has an all stainless steel design with dual basket rinse stations for cleaning utensils. Each rinse station (15 cm × 15 cm × 18 cm) has two 10 cm UV-C bulbs (254 nm at 9 mA) placed diagonally across from one another and vertically oriented. The UV-C bulb peak irradiance (i.e. maximum lamp output) is calculated as 2.2 mW/cm^2 (Rexim LLC, Boston, MA). In addition, each rinse station contains a rinse basket (14 cm × 11 cm × 10 cm) that is set in the center of the rinse station. The basic design of the RW dipper well with UV-C lamps is shown in Fig. 1. Water consumption of the RW dipper well is estimated at 0.85 L per 10 s cycle, and runs for a specified amount of time only when the utensil is placed in the rinse station.

The CF dipper well consisted of a stainless steel container placed in a sink directly under a faucet with the water turned on at full flow allowing excess to continuously spill over the edges of container. This setup was considered comparable to a commercially available CF dipper well since installing an actual dipper well sink was not feasible. The alternative of evaluating an installed CF dipper well in a foodservice establishment was not a feasible option either.

2.1. Preparation of E. coli

E. coli C-3000 (ATCC 15597, kindly provided by Dr. Kellogg Schwab at Johns Hopkins Bloomberg School of Public Health, Baltimore, MD) was grown in tryptic soy broth (TSB; Becton, Dickinson and Company, Franklin Lakes, NJ) at 37 °C with shaking at 150 rpm. Bacterial cells from overnight growth were harvested by centrifugation at 4000 × *g* for 10 min, washed two times with 0.1% buffered peptone water (BPW; pH 7.2) and then centrifuged again at 4000 × *g* for 10 min. The resulting supernatant was discarded, and the pellet was resuspended in BPW. The concentration of *E. coli* in the final resuspended pellet was determined by spread plate method on tryptic soy agar (TSA; Becton, Dickinson and Company). Inocula for all experiments were prepared in either 500 ml of dechlorinated tap water (DTW) or 500 ml of 10% skim milk (SM) media (Becton, Dickinson and Company) to a final concentration of approximately 10^6 CFU/ml. All inocula were prepared immediately prior to the experiments and were held at 4 °C for the duration of all experiments.

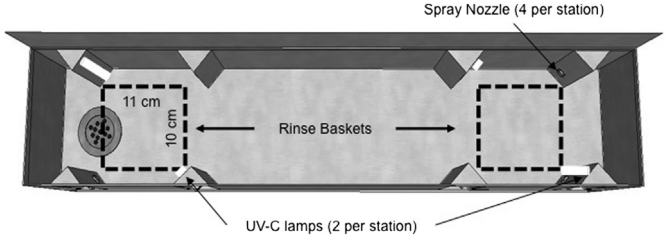

Fig. 1. Basic design of RW dipper well with UV-C germicidal lamps.

2.2. Inoculation and treatment of utensil

A sterile, foodservice-grade ice cream scoop – also referred to as a 'disher' – with the following specifications – was used for all experiments: size 20 (2 in [5 cm] bowl, or scoop, capacity), plastic handle, 18-8 stainless steel components with Agion® ionic silver technology (The Vollrath Company, L.L.C., Sheboygan, WI). For sterilization, the utensil was submersed in a 10% bleach solution for 30 s followed by submersion in a 3 M excess sodium thiosulfate (Sigma–Aldrich, St. Louis, MO) solution to inactivate the free chlorine and then a final rinse with deionized water. To verify the disinfection procedure, the utensil was swabbed, and *E. coli* were enumerated as described in Section 2.3.

For inoculation, the sterile utensil was submersed with mixing for 30 s into either DTW or 10% SM containing *E. coli* inocula and then placed in either the RW dipper well rinse station or CF dipper well reservoir for various treatment times – 5, 10, and 30 s rinse and with or without UV-C (RW dipper well only). Treatment was also evaluated over a 2 h time period in which the utensil was submersed with mixing in the inocula every 5 min and subjected to 5, 10, and 30 s rinse with or without UV-C for RW dipper well and a 30 s rinse for the CF dipper well. These specific exposure times were selected to cover a range of acceptable times for cleaning an in-use utensil during periods of service with high customer volumes. In addition, UV-C dose (i.e. radiant energy density) was calculated based on peak irradiance (2.2 mW/cm^2) and exposure time (s), and this is expressed as millijoules (mJ) per cm^2 (Mills & Raymont, 2009). All experiments were repeated in triplicate, and samples were analyzed in duplicate.

2.3. Enumeration of E. coli

For all samples – both treatment and controls – the utensil and rinse station basket (RW dipper well only) were swabbed using sterile calcium alginate tipped swabs (VWR, Radnor, PA) presoaked in BPW. The swabs were then placed in 2.25 ml of BPW, diluted, and 1 ml of each dilution was plated on 3M™ Petrifilm™ Aerobic Count Plates (3M, St. Paul, MN) per the manufacturer's instructions. All results were reported as CFU/ml based on the recovery of *E. coli* from the swab in 2.25 ml of BPW. For each set of experiments, the inoculated DTW and 10% SM medium were analyzed to determine initial *E. coli* concentrations. In addition, the utensil was swabbed at time 0 s to determine the initial *E. coli* concentrations on the utensil in order to calculate $\log_{10}$ reductions. The utensil after the sterilization procedure was also analyzed, and as an additional control, the effect of free chlorine present in tap water on the viability of *E. coli* was assessed over a 20 min period. This additional control was performed since the dipper wells utilize tap water during operation.