

SANITATION

SANITARY DESIGN OF MEAT SLICERS FOR BETTER CLEANABILITY

(G. Zhang, L. Ma, and M. P. Doyle)

The cleanability and sanitization of equipment used in meat processing is very important as insufficient cleaning and sanitation can allow foodborne pathogens such as *Listeria monocytogenes* to grow and thrive. The equipment design task force (EDTF), established by the American Meat Institute *Listeria* task force in 2001, developed “10 principles of sanitary design” of equipment, stating that the machinery must be cleanable to a microbiological level, accessible to inspection, cleaning, and sanitation, and allow no product or liquid collection. Following such principles, manufacturers of meat processing equipment can make their machinery more cleanable. Once redesigned, studies are needed to validate the cleanability of such equipment. The objective of this project was to compare the sanitary designs of different meat slicers commonly used in delicatessens.

After surveying deli departments in local grocery stores, 4 models of meat slicers from 3 different manufacturers were selected for study. Oven-roasted breasts of turkey were used in the study. The product was purchased from a local retail store, held at 4°C, and used within one week. Ingredients on the label of the product included turkey breast, turkey broth, less than two percent salt, sugar, sodium phosphate, and flavoring. Clue Spray™ is a invisible fluorescent mist used in law enforcement. It is also used for teaching how bacteria can travel about. Its main ingredients include trichloride, zinc sulfide and liquefied petroleum gas. Under long-wave ultraviolet light (wavelength, 365 nm), a green fluorescence can be observed on objects treated with Clue Spray™.

Chubs of oven-roasted turkey breast were sprayed with Clue Spray™ at ambient temperature. Thirty minutes after spraying, 25 slices of meat were cut with each machine. The sliced meat was discarded immediately. All parts of the slicer were visualized under regular light and long-wave ultraviolet light. Then the slicer was cleaned by common practices used in deli meat departments. Sanitizer was sprayed onto paper towels. All food contact surfaces were cleaned with the paper towels. New paper towels were used to dry the slicer. All parts of the slicer were visualized under regular light and long-wave ultraviolet light. Thereafter, the slicer was disassembled and removable parts were washed with detergent and hot water. All parts of the slicer were visualized under regular light and long-wave ultraviolet light again. The experiments were replicated twice.

The results revealed that for meat grips, both tooth density and materials were important. High tooth density reduced cleanability. Smooth grease-phobic surfaces improved cleanability. Removable meat grips were more desirable for cleaning. Simple and smooth bottoms of carriage trays were better for cleaning. Flat easily-accessible back sides of slicers were desirable designs for cleaning. Simple and smooth blade covers were better than complex and rough ones. All blades had too many layers and too many twists. They were not removable. Large groove and small ridge surfaces were better for cleaning. Abrupt ending of grooves was undesirable for cleaning. Blade guard ring with small openings tended to accumulate food. Guard rings that were smooth, grease-phobic and had dull edge inner sides were best.

In summary, the following designs are most desirable for cleaning: smooth grease-phobic surfaces; large groove and small ridge surfaces; no rising edge surfaces; dull smooth edges; easily accessible back side; removable grips and blades, and simple designs of all parts. There are substantial differences in the cleanability characteristics of the slicers studied. All slicers evaluated have some desirable features. Combining these desirable features into a redesigned slicer could provide a greatly improved meat slicer for cleanability.

EFFECTIVENESS OF DISINFECTANTS IN KILLING *ENTEROBACTER SAKAZAKII* IN SUSPENSION, DRIED ON THE SURFACE OF STAINLESS STEEL, AND IN BIOFILM

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The presence of *E. sakazakii* on the surface of utensils and equipment used for infant formula preparation has been reported to occur in clinical settings where neonatal infections have been documented. The ability of bacteria to form biofilms on abiotic surfaces raises the possibility that infections may occur following cross-contamination of freshly prepared infant formulas upon contact with soiled surfaces in formula preparation areas in hospitals, day-care centers, food service kitchens, and the home. Surface disinfection is routinely carried out in formula preparation areas by applying liquid chemical disinfectants to food contact and non-food contact surfaces. The

microbicidal activity of commercial surface cleaners and disinfectants is largely based on quaternary ammonium compounds, phenolic compounds, organic acids, alcohols, chlorine, and iodophors. During infant formula preparation and feeding, reconstituted formula containing *E. sakazakii* may contaminate abiotic surfaces. These surfaces may be treated with disinfectants immediately after contamination occurs, after the formula remains on the surface and dries, or after growth of *E. sakazakii* and the formation of biofilm. The efficacy of commercial disinfectants used in formula preparation areas in hospitals and child day-care centers in killing *E. sakazakii* in dried infant formula and biofilm has not been described. We undertook studies to determine the effectiveness of thirteen disinfectants in killing *E. sakazakii* in suspension, dried on the surface of stainless steel, and embedded in biofilm on stainless steel. Quaternary ammonium and phenolic disinfectants commonly used in infant formula preparation areas, laboratories, and hospital, food service, and child day-care settings were evaluated. The effects of time elapsed after drying cells on stainless steel as well as the age of biofilms on resistance of cells to disinfectants were determined. *E. sakazakii* exhibited various levels of resistance to the disinfectants, depending on the composition of the disinfectants, amount and type of organic matrix surrounding cells, and exposure time. Populations of planktonic cells suspended in water (7.22 - 7.40 log CFU/ml) decreased to undetectable levels (< 0.30 log CFU/ml) within 1 - 5 min upon treatment with disinfectants, while numbers of cells in reconstituted infant formula were reduced by only 0.02 - 3.69 log CFU/ml after the treatment for 10 min. The presence of infant formula also enhanced the resistance of cells dried on the surface of stainless steel to the disinfectants. The resistance of cells in 6-day-old and 12-day-old biofilms on the surface of stainless steel to disinfectants was not significantly different. The overall order of efficacy of disinfectants in killing *E. sakazakii* was planktonic cells > cells inoculated and dried on stainless steel > cells in biofilms on stainless steel. Findings show that disinfectants routinely used in hospital, day-care, and food service kitchen settings are ineffective in killing some cells of *E. sakazakii* embedded in organic matrices.

CHLORINE RESISTANCE OF *LISTERIA MONOCYTOGENES* BIOFILMS AND RELATIONSHIP TO SUBTYPE, CELL DENSITY AND PLANKTONIC CELL CHLORINE RESISTANCE

(J.P. Folsom and J.F. Frank)

Strains of *Listeria monocytogenes* vary in their ability to produce biofilms. This research determined if cell density, planktonic chlorine resistance or subtype are associated with the resistance of *L. monocytogenes* biofilms to chlorine. Thirteen strains of *L. monocytogenes* were selected for this research based on biofilm accumulation on stainless steel and rep-PCR subtyping. These strains were challenged with chlorine to determine the resistance of individual strains of *L. monocytogenes*. Planktonic cells were exposed to 20 through 80 ppm sodium hypochlorite in 20 ppm increments for five minutes in triplicate per replication, and the experiment was replicated three times. The number of tubes with surviving *L. monocytogenes* was recorded for each isolate at each level of chlorine. Biofilms of each strain were grown on stainless steel coupons. The biofilms were exposed to 60 ppm of sodium hypochlorite. When in planktonic culture, four strains were able to survive exposure to 40 ppm of chlorine, while four strains were able to survive 80 ppm of chlorine in at least one of three tubes. The remaining five strains survived exposure to 60 ppm of chlorine. Biofilms of 11 strains survived exposure to 60 ppm of chlorine. No association of biofilm chlorine resistance and planktonic chlorine resistance was observed, however biofilm chlorine resistance was similar for strains of the same subtype. Biofilm cell density was not associated with chlorine resistance. In addition, biofilms that survived chlorine treatment exhibited different biofilm morphologies. This data suggests that chlorine resistance mechanisms of planktonic cells and biofilms differ, with planktonic chlorine resistance being more affected by inducible traits, and biofilm chlorine resistance being more affected by traits not determined in this study.

MICROBIOLOGICAL EVALUATION OF EFFICACY OF CLEANING AND DISINFECTION PROTOCOLS FOR INFANT FEEDING BOTTLES DESIGNED FOR RURAL AFRICAN COMMUNITIES

(L. Ma, G. Zhang, A. Bowen, M.P. Doyle, and B. Swaminathan)

CDC current guidelines for infant formula preparation at home involve boiling bottles and utensils for 10-20 min before use. These guidelines have not been adopted completely in developing countries, especially in rural African communities, due to the lack of and burden of transporting sufficient firewood. Infant mortality rates remain high in these regions partly because of home-prepared infant formula being heavily contaminated with enteric pathogens. The objective of this study was to evaluate the efficacy of cleaning and chlorine disinfection protocols for infant feeding bottles designed for rural African communities. Infant formula was inoculated with a

six-strain mixture consisting of three strains each of *E. coli* and *Salmonella* at ca. 10^3 (low) or 10^6 cfu/ml (high). Infant feeding bottles containing pathogen-inoculated formula were held at 25 C for 6 h before being cleaned and disinfected. The cleaning protocols involved rinse once or twice with tap or soap water, or rinse and brush with soap water. Disinfection protocols consisted of a rinse with chlorine water (50, 125, or 200 ppm free chlorine) or submerging in chlorine water for 5, 10, or 30 min. Residual inoculated pathogens were enumerated after each treatment by direct plating and determined qualitatively by enrichment culture in universal pre-enrichment broth. Results revealed that the removal of pathogens by cleaning depended on the initial contamination level of formula. At the low cell number level, every additional 1-log reduction was obtained by rinsing once, twice, and in soap water, respectively. No further reduction at the high cell number level was achieved by rinsing twice compared to rinsing once, which produced about a 1-log reduction. However, more than a 3-log reduction was obtained with high cell number level rinsing in soap water compared to a 2-log reduction for the low cell number level. Substantial reduction of residual pathogens was obtained by submerging bottles in chlorine water for 30 min, as no pathogens could be detected by the enumeration method, but total elimination of the pathogen from the bottles was not consistently achieved. Results revealed that infant feeding bottles disinfected by chlorinated water was not completely effective but is still a practical option for improving the microbiological safety of infant formula in rural African communities.

