THERMAL INACTIVATION

FATE OF *ENTEROBACTER SAKAZAKII* ATTACHED TO OR IN BIOFILMS ON STAINLESS STEEL UPON EXPOSURE TO VARIOUS TEMPERATURES OR RELATIVE HUMIDITIES

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Concerns about the occasional presence of *Enterobacter sakazakii* in powdered infant formula have surfaced as a result of reports of outbreaks of infections associated with consumption of reconstituted products. The bacterium may enter formulas via contaminated ingredients after spray drying of milk or soy components or by cross-contamination from the environment before packaging or during reconstitution in preparation areas. *E. sakazakii* has been observed to attach to or form biofilms on the surface of silicon, latex, polycarbonate, glass, polyvinyl chloride, and stainless steel. Cells that have attached to stainless steel and formed biofilms have enhanced resistance to disinfectants. *E. sakazakii* is reported to produce extracellular polysaccharides which may enhance the resistance of cells to environmental stresses such as in low a_w environments. Meager research attention has been given to characterizing the survival of cells of *E. sakazakii* attached to abiotic surfaces or in biofilm upon exposure to dry environments.

To develop effective strategies and practices for eliminating *E. sakazakii* in processing or preparation kitchen environments, factors affecting the survival of attached cells and cells in biofilm need to be better understood. We undertook a study to determine the survival characteristics of *E. sakazakii* cells suspended in water and reconstituted infant formula and dried on the surface of stainless steel as affected by subsequent incubation temperature at 43% relative humidity (RH) for up to 60 days. Maturation curves of biofilms formed in M9 medium and reconstituted infant formula, and survival of cells in biofilms formed in these media upon exposure to RH of 23 – 100% for up to 42 days were determined.

Initial populations of 7.4 - 8.6 log CFU/coupon decreased significantly ($p \leq 0.05$) at 4, 25, and 37°C within 10, 3, and 1 day(s), respectively, but the pathogen remained viable for up to 60 days. At a given storage temperature and time, reductions were significantly greater when cells had been suspended in water rather than infant formula before drying. Formation of biofilm by *E. sakazakii* on stainless steel immersed in M9 medium, which contains minimal concentrations of nutrients, and infant formula at 25°C and subsequent survival of cells at 25°C as affected by exposure to 23, 43, 68, 85, and 100% RH were investigated. Some of the cells in these biofilms survived under all test RHs for up to 42 days. The overall order of survival as affected by RH was 100 > 23 = 43 = 68 > 85% RH, regardless of the medium in which the biofilm was formed. Reduction in viability of cells was significantly greater in biofilm that had formed in M9 medium than in biofilm formed in infant formula. Results indicate that infant formula provides protection for attached cells, as well as cells in biofilm, against lethality upon exposure to desiccation. These results are useful when predicting the survival characteristics of *E. sakazakii* on stainless steel, thereby providing insights to developing and applying effective strategies and practices for elimination of the pathogen in processing and preparation kitchen environments.

THERMAL INACTIVATION OF *SALMONELLA* IN PEANUT BUTTER

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A large multistate foodborne outbreak caused by *Salmonella* Tennessee in peanut butter was reported in 2006. The objective of this study was to determine in peanut butter the rates of thermal inactivation at different temperatures of three *S.* Tennessee strains associated with the outbreak, in comparison to strains of *Salmonella* of other serotypes (Enteritidis, Typhimurium, and Heidelberg). Commercial peanut butter was inoculated with *Salmonella* strains and heated at 71, 77, 83, and 90°C. At least three independent trials were conducted at each temperature and for each group of *Salmonella*. The thermal inactivation curves were upwardly concave, indicating rapid death at the beginning (20 min) followed by slower death rates for the remaining cells. The nonlinear Weibull model was used to fit the curves and describe the thermal inactivation of *Salmonella* in the peanut butter. The calculated minimum times needed to obtain a 5-log reduction at all temperatures for the composited three outbreak-associated strains were significantly higher ($p<0.05$) compared with those of the 5-strain mixture of other *Salmonella* serotypes. Forty-six min were needed to reduce the 3-strain mixture of *S.* Tennessee by 5-log whereas 38 min were needed for the 5-strain mixture of other *Salmonella* serotypes. These results indicate that the outbreak-associated *Salmonella* strains were more thermal tolerant than the other serotypes tested. Thermal treatments of

peanut butter at 90°C for less than 20 min are not sufficient to kill large populations of *Salmonella* in highly contaminated peanut butter.