Strategic Innovation of Nanotechnology: Novel Applications of Biomimetics and Microfluidics in Food Safety

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Abstract : Strategic innovation of nanotechnology to promote food safety has drawn tremendous attentions among research groups, which includes the need for research support during the implementation of the Food Safety Modernization Act (FSMA) in the United States. There are urgent demands and knowledge gaps to the understanding of a) food-water-bacteria interface as for how pathogens persist and transmit during food processing and storage; b) minimum processing requirement needed to prevent pathogen cross-contamination in the food system. These knowledge gaps are of critical importance to the food industry. However, the lack of knowledge is largely hindered by the limitations of research tools. Our groups recently endeavored two novel engineering systems with biomimetics and microfluidics as a holistic approach to hazard analysis and risk mitigation, which provided unprecedented research opportunities to study pathogen behavior, in particular, contamination, and cross-contamination, at the critical food-water-pathogen interface. First, biomimetically-patterned surfaces (BPS) were developed to replicate the identical surface topography and chemistry of a natural food surface. We demonstrated that BPS is a superior research tool that empowers the study of a) how pathogens persist through sanitizer treatment, b) how to apply fluidic shear-force and surface tension to increase the vulnerability of the bacterial cells, by detaching them from a protected area, etc. Secondly, microfluidic devices were designed and fabricated to study the bactericidal kinetics in the sub-second time frame (0.1~1 second). The sub-second kinetics is critical because the cross-contamination process, which includes detachment, migration, and reattachment, can occur in a very short timeframe. With this microfluidic device, we were able to simulate and study these sub-second cross-contamination scenarios, and to further investigate the minimum sanitizer concentration needed to sufficiently prevent pathogen cross-contamination during the food processing. We anticipate that the findings from these studies will provide critical insight on bacterial behavior at the food-water-cell interface, and the kinetics of bacterial inactivation from a broad range of sanitizers and processing conditions, thus facilitating the development and implementation of science-based food safety regulations and practices to mitigate the food safety risks.

Keywords : biomimetic materials, microbial food safety, microfluidic device, nanotechnology
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