Characterize the formation of volatile disinfection byproducts and chlorinated tyrosine during fresh produce washing

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Drinking water disinfection plays a critical role protecting human population from waterborne diseases caused by microbiological contamination. In the process of disinfection, chemical disinfectants inactivate pathogenic organisms with their oxidizing ability; however, the same process also produces environmentally hazardous chemicals called disinfection byproducts (DBPs), as disinfectants react with precursors in the source water, such as organic carbon. Many DBPs are mutagenic, genotoxic, carcinogenic, clastogenic and developmentally toxic, and consumption of disinfected water is associated with bladder cancer and adverse pregnancy outcomes in human epidemiological studies. The chemical disinfectant most commonly utilized in municipal drinking water plants is hypochlorite/hypochlorous acid, collectively known as free chlorine. Food processing facilities in the United States also wash vegetables with free chlorine to prevent foodborne diseases. However, the formation of DBPs and/or chemical modification of the content of the fresh produce have not been fully characterized. Compared to the mg/L organic carbon content of traditional drinking waters, fresh produce represents nearly kg/L concentrations of precursors, and these precursors are fresh biomolecules whose byproducts can be more readily predicted. Leaf vegetables such as lettuce are often cut during food processing, and the contents can leach out into wash water, which also enables access of the free chlorine to the inner content of lettuce leaves. The formed byproducts could be washed off, or stay on lettuce as residues, remaining bioavailable to consumers. This study investigated DBPs generated as food residues and in the process water. Treating cut lettuce with free chlorine resulted in the formation of multiple volatile DBPs, such as halomethanes, haloacetonitriles, haloamides, haloaldehydes and haloketones. The study also investigated modification of tyrosine residues in protein. While volatile DBPs may disappear before reaching consumers, oxidation products from free amino acids and/or amino acid residues in protein in lettuce are not as volatile, and may remain on the produce as food residues to the point of consumption. Among several amino acids, tyrosine is one of the most reactive ones, and halogenated materials are often associated with higher toxicity. Results of this project lead to a better understanding of potential health risks associated with exposure to DBPs from food source, and to the reduction of environmental impacts of DBPs in food processing facility effluents.