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Formation of volatile halogenated compounds in fresh-cut cabbage treated with sodium hypochlorite

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Abstract

This study was conducted to investigate factors affecting the formation of disinfection by-products in fresh-cut cabbage during sodium hypochlorite treatment. Fresh cabbage was disinfected with a sodium hypochlorite solution (100 mg/L) for 10 min, with and without organic acids. Volatile organic compound residues in the fresh-cut cabbage were analyzed using headspace GC/MS. Chloroform was detected as the main by-product. Chloroform formation was dependent on contact time, pH, temperature and initial concentration of sodium hypochlorite solution. The use of sodium hypochlorite solution in combination with hydrochloric acid or some organic acids did not affect chloroform formation, except that citric acid reacted with hypochlorite to produce large amount of chloroform. When the citric acid was coupled with sodium hypochlorite solution, the chloroform level in the sample was dependent on the pre-mixing time of the solution, but was independent on the contact time of the mixed solution with the sample. Rinsing with water effectively reduced chloroform contaminants in the fresh-cut cabbage to the levels of chlorinated drinking water.

Keywords : trihalomethanes, chloroform, sodium hypochlorite, cabbage, citric acid

I. Introduction

Sodium hypochlorite is used as a disinfectant in the processing of fruits, vegetables, and other fresh foods. Chlorine is also widely used as a disinfectant for drinking water, and it is well known that chlorine reacts with natural organic compounds in water, resulting in the formation of trihalomethanes (THM)[1, 2]. THM are a group of chemicals that commonly include chloroform, bromodichloromethane (BDCM), dibromochloromethane (DBCM) and bromoform. The presence of THM in drinking water is a human health concern. The US Environmental Protection Agency (USEPA) has set the maximum contaminant level for total THM at 80 μg/L as the locational running annual average[3]. The European Union drinking water directive (98/83/EC) has set the maximum standard for total THM at 100 μg/L[4], while the World Health Organization (WHO) has announced the drinking water guidelines for chloroform (300 μg/L), BDCM (60 μg/L), DBCM (100 μg/L) and bromoform (100 μg/L)[5]. The Ministry of Health, Labour and Welfare of Japan has set the maximum contaminant level of total THM at 100 μg/L, for chloroform at 60 μg/L, for BDCM at 30 μg/L, for DBCM at 100 μg/L, and bromoform at 90 μg/L[6].

The U.S. Food and Drug Administration (FDA) has monitored residual chemical contaminants in foodstuffs through the total diet programs for over 40 years. THM and other chlorinated volatile organic compounds (VOC) have been detected in several foodstuffs, including butter, cheese, margarine and soft drinks[7-11]. Several studies have reported that treatment with chlorine solution on poultry, milk and fresh-cut vegetables may induce the formation of reaction by-products[12-16]. Huang *et al.* investigated the THM formation potentials of foods and beverages during production with chlorinated drinking water and observed that THM were formed in the preparation and cooking of foods[17]. Recently, Klaiver *et al.* and Lopez-Galvez *et al.* investigated effective washing procedures for microbe removal, and residual THM content in fresh foods[18, 19].

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