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Influence of different organic materials on chlorine concentration and sanitization of slightly acidic electrolyzed water

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ABSTRACT

The objective of the present study was to determine the effect of organic materials on chlorine concentration through *in vitro* assays to identify the most critical organic material affecting the sanitization of slightly acidic electrolyzed water (SAEW) during washing process. Organic materials (100–1000 mg/L) were added into SAEW solution and consumption of free chlorine was recorded. Inactivation of pathogens was performed in present of these organic materials. Depletion of free chlorine and sanitization efficacy of SAEW were determined during vegetables and meats samples washing processes. Results of this study showed that protein compounds had more detrimental effects on sanitization efficacy than lipids and carbohydrates. In the presence of carbohydrate and lipid compounds, pathogen population were decreased below the detection limits within 3 min. However, SAEW effect was decreased with increasing protein concentration. During simulation of washing processes, free chlorine was more quickly consumed in reactions containing organic materials for meats compared to those for vegetable produce. However, such difference in chlorine depletion did not significantly influence bacterial reduction between meats and vegetable produce. These results indicate that the optimization of SAEW washing should consider both the amount and the type of organic materials constituting the fresh produce.

1. Introduction

Water washing is an important step during fresh produce processing to remove dirt, debris, and cell exudates from food products. It is also used to decrease the microbial load of the product (Gómez-López, Gil, & Allende, 2017). This step must be followed or combined with washing of fresh produce with a sanitizer solution. Despite the constantly realized progress in the food industry, safety concerns about raw and processed food have heightened due to multiple foodborne illness outbreaks in recent decades (Jensen, Friedrich, Harris, Danyluk, & Schaffner, 2015). Appropriate use of a disinfectant is necessary for reducing the number of foodborne outbreaks by controlling pathogenic bacteria load and preventing cross-contamination. One of the most disinfectants use in food industry is sodium hypochlorite disinfectant. It has advantages in comparison with other inactivation technologies, because it can reduce microbial load without affecting quality of food and it is available anywhere at low cost (Luo et al., 2012).

Chlorine is a strong oxidant sanitizing agent. However, it can reacts with organic materials, leading to the formation of trihalomethanes (Gómez-López et al., 2017) which will decrease its sanitation efficacy (Gil, Gómez-López, Hung, & Allende, 2015; Yang, Luo, Millner, Shelton, & Nou, 2012). This is especially problematic for fresh produce washing as wash solutions contain a large amount of organic matter from cut-produce or damaged tissue exudates, soil, and other plant debris. Free chlorine refers to the chlorine that is available for disinfection. It is not bound to organic compounds (Nakajima et al., 2004). Free chlorine play an important role in the ability of chlorine to kill microorganisms. Combined chlorine refers to chlorine that can be consumed in a reaction with organic and inorganic nitrogen to form chloramines (White, 1999). Combined chlorine has much lower in antimicrobial activity compare to free chlorine (Gil et al., 2015; Gómez-López et al., 2017; Zhou, Luo, Nou, Lyu, & Wang, 2015).

Recent studies have emphasized that electrolyzed water (EW) has potential to replace traditional chlorine treatment. EW is an oxidant sanitizer with free chlorine as its main antimicrobial agent. It is non-thermally produced by electrolysis of a dilute salt solution (generally sodium chlorite and/or hypochlorous acid) through an electrolytic cell. When the electrolysis cell does not contain the membrane between anode and cathode, the resulting solution is known as slightly acidic electrolyzed water (SAEW) with a pH from 5.0 to 6.5. This pH decreases

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Table 1
Consumption of free chlorine in reaction with different organic materials during 5 min.

Organic materials	Concentration (mg/L)	Total chlorine (mg/L)	Free chlorine (mg/L)	Combined chlorine (mg/L)	pH
–	0	31.33 ± 0.58	31.00 ± 0.00	00.33 ± 0.58	5.69 ± 0.05
Beef extract	100	29.00 ± 1.00	18.33 ± 0.58	10.67 ± 1.53	
	300	28.00 ± 1.00	12.33 ± 0.58	15.67 ± 1.15	
	500	27.66 ± 0.81	8.33 ± 0.58	19.33 ± 1.39	
	700	27.33 ± 1.15	6.33 ± 0.58	21.00 ± 1.00	
	1000	27.00 ± 0.58	3.67 ± 1.15	23.33 ± 1.53	
Peptone	100	29.33 ± 1.15	18.67 ± 2.31	10.67 ± 1.15	
	300	29.00 ± 0.58	14.34 ± 0.58	14.67 ± 0.58	
	500	28.33 ± 0.58	13.33 ± 0.58	15.00 ± 0.00	
	700	28.00 ± 0.00	6.67 ± 0.58	21.33 ± 0.58	
	1000	27.67 ± 0.58	2.67 ± 1.15	25.00 ± 1.00	
Tryptone	100	30.33 ± 0.58	17.00 ± 1.00	13.33 ± 1.53	
	300	29.00 ± 0.00	15.00 ± 1.00	14.00 ± 1.00	
	500	29.00 ± 1.00	12.33 ± 1.15	16.67 ± 2.08	
	700	28.67 ± 1.15	8.67 ± 1.15	20.00 ± 2.00	
	1000	26.67 ± 0.00	4.33 ± 1.00	22.33 ± 1.53	
Cellulose	1000	30.00 ± 0.00	29.33 ± 0.06	0.67 ± 0.05	
Fructose		29.67 ± 0.05	29.66 ± 0.06	29.66 ± 0.06	
Glucose		29.33 ± 0.05	29.00 ± 0.15	29.00 ± 0.15	
Corn oil		29.67 ± 0.04	21.33 ± 0.05	21.33 ± 0.05	
Glycerin		29.33 ± 0.04	23.33 ± 0.58	23.33 ± 0.58	

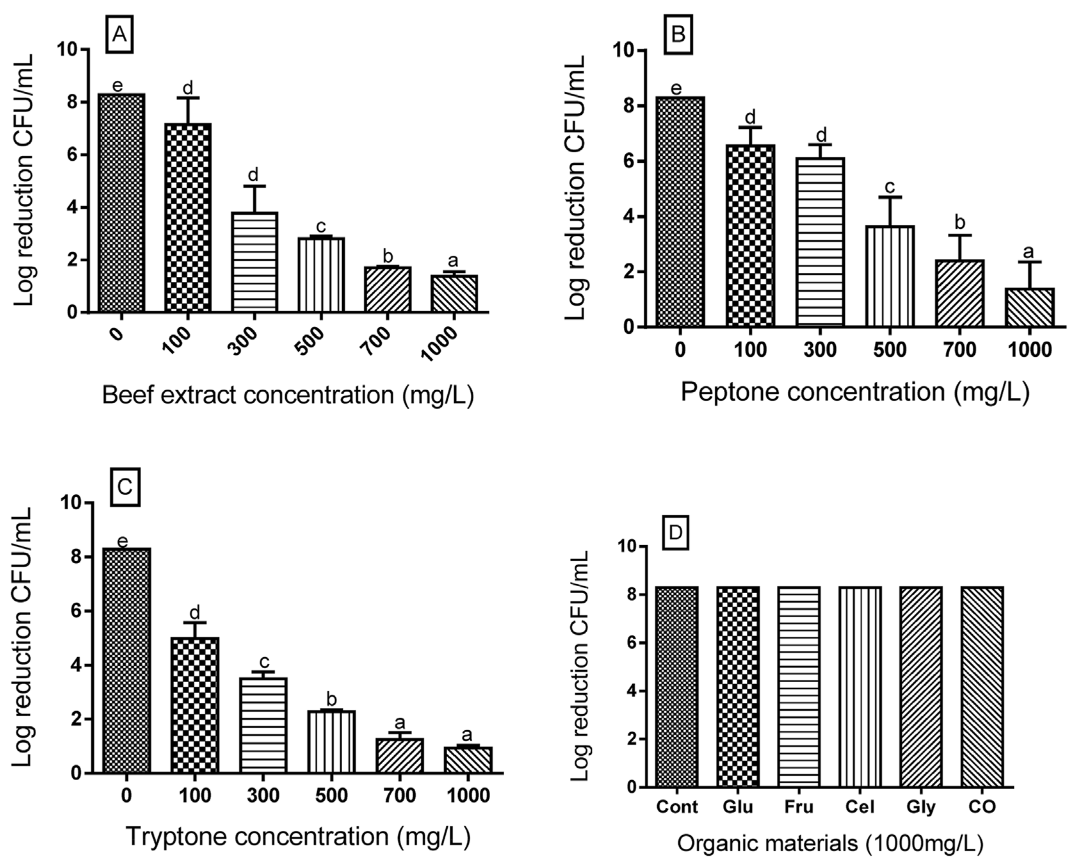

Fig. 1. Effect of organic materials on sanitization efficacy of slightly acidic electrolyzed water against *Bacillus cereus*. A: Peptone; B: Tryptone; C: Beef extract; D: Carbohydrate and Lipid. Glu: glucose, Fru: fructose, Cel: cellulose, Gly: glycerol, and CO: corn oil.

the environmental and corrosive impact of processing surface in fresh produce industry. The sanitizing ability of SAEW to inactivate spoilage and pathogenic bacteria on cereal, meats, and fresh produce have been comprehensively studied and confirmed (Issa-Zacharia, Kamitani, Miwa, Muhimbula, & Iwasaki, 2011; Pinto, Ippolito, & Baruzzi, 2015; Rahman, Park, Song, Al-Harbi, & Oh, 2012; Tango, Wang, & Oh, 2014). SAEW has been highlighted as one of the alternative sanitizers because since it can simply be produced simply on-site and its raw materials (water, NaCl and/or HCl) are cheap and available everywhere (water, NaCl and/or HCl) and it generates low trihalomethane compound (Gil et al., 2015; Gómez-López et al., 2017).

In practical usage, SAEW is generally used to inactivate microorganisms in food matrix containing organic materials. These organic materials can potentially react with the available chlorine in SAEW and change it to the combined chlorine. Therefore, in the presence of organic materials, the expected antimicrobial activity of SAEW is not