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Effect of different sanitizers on the microbial load and selected quality parameters of "chile de árbol" pepper (*Capsicum frutescens* L.) fruit

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ABSTRACT

The aim of this work was to evaluate the effectiveness of different substances used as sanitizers for "chile de árbol" (*Capsicum frutescens* L.) fruit by means of their effect on microbial load as well as on fruit physicochemical and sensory properties. Sodium hypochlorite (100–10,000 mg L^{-1}), hydrogen peroxide (5%), ethanol (70%), nisin (125 mg L^{-1}), and a commercial lineal anionic surfactant (2%) were used to sanitize pepper fruit. Different exposure times were evaluated for selected sanitizers. Ratios of 1:10 of fruit- solutions were utilized for the sanitization processes. After sanitization, microbiological analyses were performed (total mesophilic aerobic bacteria (TMAB), lactic acid bacteria (LAB), molds, and yeasts); in addition, color (L^*, a^*, b^*), texture (peel's break force and peel's hardness), pH, and titratable acidity were determined on pepper fruits. In addition, a sensory evaluation was performed. Medium (1000 and 2000 mg L^{-1}) and high (10,000 mg L^{-1}) sodium hypochlorite concentrations reduced about 2 $\log_{10}$ cycles of TMAB. Molds only were reduced when high concentrations of sodium hypochlorite were used. The most effective sanitizer was ethanol, reducing 4.7 $\log_{10}$ of TMAB, 4.2 $\log_{10}$ of LAB, 2.5 $\log_{10}$ of molds, and 2.7 $\log_{10}$ cycles of yeasts when exposure time was 120 min, and final counts were <100 CFU g^{-1} for TMAB, and <10 CFU g^{-1} for LAB, molds, and yeasts. Hydrogen peroxide generated the greatest losses of greenness and texture of treated pepper fruit. The pH increased ($\Delta pH = 0.2$) when high concentrations of sodium hypochlorite were used. The sanitization processes did not affect lightness and titratable acidity. Judges detected losses in greenness of pepper fruits sanitized with hydrogen peroxide (5%, 30 or 120 min), sodium hypochlorite (10,000 mg L^{-1}, 120 min), or ethanol (70%, 30 min); losses in firmness for pepper fruits treated with hydrogen peroxide (5%, 30 min) or nisin (125 mg L^{-1}, 120 min); but noticed increments ($p < 0.05$) of peppers' pungent smell sanitized with hydrogen peroxide (5%, 30 or 120 min) and sodium hypochlorite (10,000 mg L^{-1}, 120 min). Peppers' brightness did not change ($p > 0.05$) after treatments.

1. Introduction

Pepper (*Capsicum annuum*) fruits have been domesticated as a crop in several regions of Mexico since pre-Hispanic times (Kraft et al., 2014). Today, a wide range of pepper fruits is available in Mexican markets and is commonplace in Mexican diets. The most cultivated pepper fruits in Mexico are jalapeño (*Capsicum annum* var. *annuum* L.), poblano (*Capsicum annum* var. *annuum* L.), serrano (*Capsicum annum* var. *annuum* L.), chilaca (*Capsicum annum* var. *annuum* L.), de árbol (*Capsicum frutescens* L.), habanero (*Capsicum chinense* Jacq.), and piquín (*Capsicum annuum* var. *glabriusculum)* (SIAP, 2015). Mexico's mean production of green chilies and peppers from 2010 to 2013 was 2 285 359.50 tons, placing it as the second top producer in the world (FAOSTAT, 2015). One of the most consumed peppers in Mexico is "chile de árbol". Typical uses are as a pungent ingredient in several sauces, like the famous Mexican salsa and guacamole. Also it is an ingredient in green sauces used to prepare meals with beef, pork, or poultry meats; some people eat "chile de árbol" as any other fresh fruit during their meals.

Ideal postharvest handling is storing pepper fruits under refrigeration after harvest during transport, storage, distribution, etc.; in order to maintain pepper fruit freshness. For a shelf life of 3–5 weeks the optimal storage temperature is 7.5 °C and relative humidity > 95% (Cantwell, 2013). Despite the aforementioned, local markets or small vegetables stands offer pepper fruits at room temperature and their shelf life is shorter (5–7 days). Pepper fruits are mainly spoiled by *Botrytis*, *Alternaria*, and soft-rot bacteria; *Botrytis* can be controlled by immersing pepper fruits in hot water

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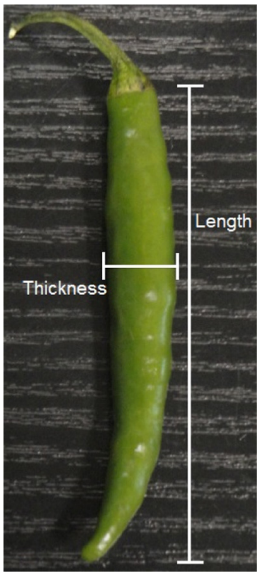

Fig. 1. “Chile de árbol” fruit length and thickness.

(55 °C) for 4 min (Cantwell, 2013). Furthermore, mechanical damage (crushing, perforations caused by splinters, scratches, etc.), is very common in pepper fruits which favors rotting.

The US Food and Drug Administration established the use of chlorine (50 – 200 mg L^{-1} total chlorine), at a pH of 6.0 – 7.5, with a contact time of 1 – 2 min as disinfection processes for harvested fresh produce. Several studies had shown that chlorine used at the levels recommended by the FDA lacks the effectiveness necessary to eliminate spoilage microorganisms. In addition, chlorine could react with organic matter in water to form carcinogenic compounds (Parish et al., 2003). Several researchers have proposed alternative sanitization processes for fruits and vegetables, while testing acidified sodium hypochlorite (Sanz et al., 2002; Allende et al., 2009), hydrogen peroxide (Silveira et al., 2008; Perez et al., 2012), peracetic acid (Walter et al., 2009; Neal et al., 2012; Bachelli et al., 2013), nisin + EDTA (Silveira et al., 2008), ozone (Neal et al., 2012; Amaral et al., 2012; Bachelli et al., 2013; Sengun, 2013), L-lactic acid (Neal et al., 2012), acetic acid (Perez et al., 2012), ethyl alcohol (Perez et al., 2012), carvacrol (Ruiz-Cruz et al., 2010), and silver-based products (Beltran et al., 2013). These authors have obtained diverse results because these depend on the type of fruits or vegetables, target microorganisms, type and concentration of tested sanitizers, time of exposure, initial microbial load, among others. When the fruit has a waxy surface some authors have suggested the use of surfactants, detergents, and solvents, alone or coupled with physical manipulation such as brushing, in order to reduce hydrophobicity or remove part of the wax to increase exposure of microorganisms to sanitizers, such treatments may cause deterioration of sensory quality, thereby limiting their usefulness to applications just prior to consumption (Parish et al., 2003). Few studies have focused on sanitization processes for peppers such as fresh-cut jalapeño and bell peppers (Ruiz-Cruz et al., 2010; Perez et al., 2012; Amaral et al., 2012; Beltran et al., 2013); thereby new insights are necessary regarding these fruits. The aim of this work was to evaluate the antimicrobial effectiveness of sodium hypochlorite at FDA recommended levels, consumer-available antimicrobials (H_2O_2 and ethanol) and nisin, all of which could be used as sanitizers in “chile de árbol” (*C. frutescens* L.) with lengthy exposure times in order to maximize the reduction of the pepper's initial microbial load while detecting changes on selected physicochemical and sensory properties.

2. Materials and methods

2.1. “Chile de árbol” fruit

Fresh “chile de árbol” fruits (*C. frutescens* L.) were purchased at a local market in Puebla, Mexico. Fruits were sorted to eliminate damaged and poor quality fruits. Pepper fruits were selected to obtain products of similar size, shape, and color. “Chile de árbol” peppers were rinsed with tap water to remove residual soil. Portions of 50 g (15 fruits, approximately) were taken and washed in the tested sanitizer solutions as described below.

2.2. Physical properties

Fifty pieces of pepper fruits were measured with a digital Vernier caliper (Mitutoyo Corp., Kawasaki, Japan) in order to determine the fruit's length and thickness at the equatorial axis as shown in Fig. 1. In addition, the fruit's weight was determined with an analytical balance (AY220, Shimadzu, Japan).

2.3. Sanitization process

“Chile de árbol” fruits were submerged in solutions according to the experiments presented in Table 1, in every case the ratio used was 10 mL of solution per gram of fruit. Sanitizers used in the study were sodium hypochlorite (Cloralex, NL, Mexico, 6% NaOCl), hydrogen peroxide (Fermont, NL, Mexico, 30%), and ethanol (RBM,

Table 1
Sanitization conditions tested in the study; pH and titratable acidity of “chile de árbol” fruits after sanitization processes (values are presented as an average of six measurements ± the standard deviation).

Sanitizer	Concentration	Immersion time	pH	% titratable acidity
Tap water	–	2 min	6.01 ± 0.02^{c}	0.17 ± 0.01^{a}
Surfactant (S)	2%	2 min	6.31 ± 0.01^{ab}	0.11 ± 0.02^{a}
Sodium hypochlorite	100 mg L^{-1}	5 min	6.30 ± 0.01^{ab}	0.13 ± 0.02^{a}
Sodium hypochlorite	200 mg L^{-1}	5 min	5.99 ± 0.01^{c}	0.13 ± 0.01^{a}
Sodium hypochlorite	500 mg L^{-1}	5 min	6.31 ± 0.06^{ab}	0.15 ± 0.02^{a}
Sodium hypochlorite	1000 mg L^{-1}	10 min	6.27 ± 0.04^{ab}	0.14 ± 0.04^{a}
Sodium hypochlorite	2000 mg L^{-1}	10 min	6.00 ± 0.03^{c}	0.11 ± 0.00^{a}
S +sodium hypochlorite	2000 mg L^{-1}	10 min	6.17 ± 0.01^{bc}	0.12 ± 0.01^{a}
S +sodium hypochlorite	4000 mg L^{-1}	10 min	6.16 ± 0.02^{bc}	0.12 ± 0.03^{a}
Ethanol	70%	30 min	6.38 ± 0.01^{ab}	0.12 ± 0.00^{a}
Sodium hypochlorite	10,000 mg L^{-1}	30 min	6.44 ± 0.02^{a}	0.12 ± 0.00^{a}
Hydrogen peroxide	5%	30 min	6.31 ± 0.05^{ab}	0.11 ± 0.03^{a}
Ethanol	70%	120 min	6.21 ± 0.04^{abc}	0.15 ± 0.02^{a}
Sodium hypochlorite	10,000 mg L^{-1}	120 min	6.37 ± 0.01^{ab}	0.12 ± 0.02^{a}
Nisin	125 mg L^{-1}	120 min	6.31 ± 0.21^{ab}	0.12 ± 0.03^{a}

Data in the same column followed by different letters are significantly different ($p < 0.05$).