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Synergistic effect of vitamin B_1 on sanitizer and disinfectant treatments for reduction of coliforms in rice

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Abstract

The synergistic bactericidal effect of vitamin B_1 (thiamin dilauryl sulfate) and the efficacy of commercial sanitizers and disinfectants for minimization of the contamination of total mesophilic bacteria and coliforms in rice were investigated. Water-treated rice exhibited a 0.7 $\log_{10}$ CFU/g reduction in both total mesophilic bacteria and coliforms. Reduction in sanitizer-treated rice was greater than for water-treated rice and reduction in sanitizer-treated rice with vitamin B_1 was even greater than for sanitizer-treated rice. Coliforms in cooked rice after treatments with 5000 ppm hydrogen peroxide with 1000 ppm vitamin B_1, 100 ppm chlorine with 800 ppm vitamin B_1, 150 ppm chlorine with 500 ppm vitamin B_1, 200 ppm chlorine with 100 ppm vitamin B_1, and finally 100,000 ppm ethanol with 800 vitamin B_1 were completely eliminated. The sensory properties of the above-mentioned sanitizer-treated cooked rice did not differ significantly from the same properties for water-treated cooked rice.

Keywords: Rice; Total mesophilic bacteria; Coliforms; Sensory evaluation; Sanitizers and disinfectants; Vitamin B_1 (thiamin dilauryl sulfate)

1. Introduction

Cooked rice has been the staple food in Korea since ancient times. Rice (*Oryzae sativa* L.) is also the principle food for more than 40% of the world population. Rice has been used in processed foods such as a cakes, gruels, snacks, beverages, and alcoholic drinks for many years. Since the rice cake was first introduced into the Korean market in 1987, processed rice products have diversified to include instant noodles, fermented sweet rice drinks, instant cooked rice, rice gruel, and rice beverages (Ahn, 1992).

An average of 87 kg of rice is used per person per year in Korea out of a total 99 kg of grain used per person in 2002. Per year per capita consumption of rice in 2000 was greater in Korea (93.6 kg) than in both Japan (64.6 kg) and Taiwan (52.7 kg) (MAF, 2005).

Coliforms, which are widely distributed in nature in soils, plants, surface waters, and in the intestinal tracts of homoiothermic animals, are Gram-negative rods. They can influence food preservation and safety because these organisms are indicators of fecal contamination. According to the Korea Food Code, if coliforms are isolated from rice, the rice can be used to make noodles and suchlike experienced in heating process. Use of raw rice and rice flour are very limited because coliforms should not be isolated from generally processed foods legally.

According to Piernas and Guiraud (1997), 7.45 log CFU of total mesophilic bacteria, 3.08 log CFU of total coliforms, 2.28 log CFU of thermotolerant coliforms, 1.30 log CFU of Enterococci, and 4.41 log CFU/g of yeasts and molds were present in studied rice. Sarrias, Valero, and Salmeron (2003) noted studied rice contaminated with 5.09 log CFU of total mesophilic bacteria, 1.39 log CFU of total coliforms, 1.43 log CFU of *Bacillus cereus*, and 0.72 log CFU/g of yeast and mold. Recently, Chang et al. (2004a) reported rice contamination with 4.96 log CFU of total mesophilic bacteria, 2.78 log CFU of total coliforms, 1.90 log CFU of *B. cereus*, and 3.56 log CFU/g of yeast and mold.

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Brown rice and sticky rice, which are the main ingredients of *Saengshik*, a raw grain meal in Korea, were contaminated with 3.7 (brown rice) and 2.7 (sticky rice) log CFU of total mesophilic bacteria, 1.3 (brown rice) and 1.8 (sticky rice) log CFU of total coliforms, and 2.5 (brown rice) and 1.4 (sticky rice) log CFU/g of *Staphylococcus aureus* (Chang, Han, Song, Chung, & Shin, 2004b). Wheat contained 1–7 log CFU of total mesophilic bacteria, 0–3 log CFU of total coliforms, 2–5 log CFU of *Bacillus* spp, 2–3 log CFU/g of yeasts, and 2–3 log CFU/g of molds (Berghofer, Hocking, Miskelly, & Janssom, 2003).

Physical sanitization and disinfection methods, such as heating (Browne & Dowds, 2001), electron beam irradiation (Sarrias et al., 2003), chemical sanitizing, and disinfectant methods using chlorine, hydrogen peroxide, ethanol, and ozone (Beuchat, 1997; Chang et al., 2004a; Mermelstein, 1998; Piernas & Guiraud, 1998; Wisniewsky, Glatz, Gleasin, & Reitmeier, 2000) have been used to reduce the amounts of coliforms and pathogenic bacterial contamination in foods. Most of all wet noodle manufacturing companies in Korea uses ethanol to prolong shelf-life of the products legally. As well as vitamin B_1, a food additive is being widely added to noodle as a synergistic anti bactericidal preservative by decreasing concentration of ethanol due to the flavor problem. Kim, Cho, and Lee (2005) reported the antimicrobial activities of vitamin B_1 against *Escherichia coli* as well as *Staphylococcus aureus*. Therefore, this study was designed to verify a synergistic bactericidal effect of vitamin B_1 and to determine the efficacy of commercial sanitizers and disinfectants for minimizing contamination of coliforms in rice.

2. Materials and methods

2.1. Rice samples

Ansungmachum, a kind of polished rice, was sealed in packages to prevent loss of moisture for use in this study. Ten g of each sample was placed in a stomacher bag with 40 ml of 0.1% peptone water and evenly mixed using a stomacher (Elmex SHII M, Tokoy, Japan) at medium speed for 1 min. One ml samples were serially diluted 10-fold in 0.1% peptone water from 10^{-1} to 10^{-3}.

2.2. Quantitative analysis of total mesophilic bacteria and coliforms

One ml of the 10^{-1}, 10^{-2}, and 10^{-3} dilutions was plated in both tryptic soy agar (TSA, Difco, USA) and violet red bile agar (VRBA, Difco, USA). Diluted samples were aseptically placed in a petri dish. Approximately 15–20 ml of tryptic soy agar (TSA, Difco, USA) and violet red bile agar (VRBA, Difco, USA) were poured into the petri dishes containing 1 ml of the dilutions for analysis of total mesophilic bacteria and coliforms, respectively. The plates were incubated at 37 °C for 24–48 h. After incubation, colonies that appeared on the plates were counted as standard plates counts (SPC). Results were expressed as log colony-forming units (CFU)/g.

2.3. Sanitizing solutions

The tested sanitizers were hydrogen peroxide (Huwa-san TR-50, Roam Chemical NV, Belgium), chlorine (Kirby-chlor, Schering–Plough Ltd., England), quaternary ammonium compounds (QAC, Akzo Qrquad MCB-80, Namkang, Korea), ethanol (fermented ethanol 95%, Korea Ethanol Supplies Co., Korea), and calcium oxide (Yaizu Suisan Kagaku Industry Co. Ltd., Japan). The sanitizers were all diluted with tap water to their respective normal target concentrations of 100–24,000 ppm hydrogen peroxide, 100–200 ppm chlorine, 30–180 ppm QAC, 10–30% ethanol, and 100–1800 ppm calcium oxide. Vitamin B_1 (thiamin dilauryl sulfate) was dissolved in 30% ethanol and the solution was immediately added to the sanitizers.

2.4. Evaluation of sanitizers and disinfectants

To perform inactivation tests for the sanitizers, 10 g of white rice was washed with sterile distilled water for 2 min, treated with the sanitizers for 5 min, then rinsed with sterile distilled water for 2 min. The rice was finally neutralized using D/E neutralizing broth (Difco, USA) then the total aerobic bacteria and coliforms with TSA and VRBA were enumerated.

2.5. Evaluation of sensory characteristics

The sensory evaluation of both water-treated cooked rice and sanitizer-treated cooked rice was performed after treatments with 500–24,000 ppm hydrogen peroxide, 300 ppm chlorine, 30–200 ppm QAC, 100,000–400,000 ppm ethanol, and 500–2000 ppm calcium oxide. The sensory characteristics of color, odor, taste, and overall acceptability of cooked rice after sanitizer treatments were evaluated by 10 trained panelists using a 9 point hedonic scale (5 represented a control; 1 represented inferiority; 9 represented excellence). Sensory characteristics were then compared with a water treated cooked rice control. The panelists rinsed their mouths after evaluating each sample. Data from the sensory evaluation were analyzed using statistical analytical software (SAS, SAS Institute, version 8.1). Average values and significance were analyzed using Duncan's multiple range test.

3. Results and discussion

3.1. Microbiological evaluation

3.1.1. Synergistic effects of vitamin B_1 with hydrogen peroxide

Table 1 shows the reduction of total mesophilic bacteria and coliforms in raw rice after hydrogen peroxide (100–20,000 ppm) treatment with 100–1000 ppm vitamin B_1.