

# Effect of sodium bicarbonate on *Staphylococcus aureus* during high hydrostatic pressure treatment and storage under a low temperature condition

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**Objective:** High hydrostatic pressure (HHP) processing is a non-thermal food preservation technique that inactivates microorganisms responsible for foodborne diseases and food spoilage by subjecting foods to pressures, with or without heat, that has a minimal effect on taste, texture and nutritional characteristics. *S. aureus* is one of the most barotolerant species to HHP treatment and not inactivated after HHP treatment even at 400-600 MPa. Thus, *S. aureus* survives under high pressure conditions and is extremely difficult to be completely sterilized by HHP treatment. Sodium bicarbonate (NaHCO<sub>3</sub>) is widely used in food processing and is known to be effective in tenderizing meat when used with HHP treatment, but its effect on microorganisms has not been investigated. The aim of this study is to clarify the effectiveness of adding NaHCO<sub>3</sub> in HHP treatment on the sterilization of *S. aureus* and its growth during storage. At first, we examined the effect of NaHCO<sub>3</sub> using a liquid medium under various conditions. Next, we examined whether the conditions that were found to be effective in the liquid medium were effective in meat.

**Materials and Methods:** Brain Heart Infusion (BHI) broth added with 0.1-0.7 M NaHCO<sub>3</sub> and inoculated with *S. aureus* NBRC12732 at 10<sup>6</sup> CFU/mL was subjected to HHP treatment at 400 MPa for 10-30 min at room temperature by using a HHP processor and then incubated for 30 d and 36 h at 10°C and 37°C, respectively. The bacteria were inoculated to NaHCO<sub>3</sub>-added BHI broth, also subjected to HHP treatment at 600 MPa for 5 min at room temperature under the commonly used a HHP treatment condition and incubated for 30 d at 10°C. In addition, beef samples soaked in 0.4 M and 0.7 M NaHCO<sub>3</sub> solutions for 40 min were inoculated with *S. aureus* and subjected to HHP treatment at 400 MPa for 10 min at room temperature, which were stored at 10°C. Bacterial counts were determined by the plate or mixed culture method (detection limit: 1.0 × 10<sup>0</sup> CFU/mL).

**Results and Discussion:** First, the effect of NaHCO<sub>3</sub> on *S. aureus* was examined during HHP treatment at 400 MPa in a liquid medium. As the HHP treatment time increased, the number of bacteria after the HHP treatment tended to decrease. There were no differences in the number of bacteria after HHP treatment with and without NaHCO<sub>3</sub>, although the number of bacteria decreased slightly depending on NaHCO<sub>3</sub> concentrations. Thus, NaHCO<sub>3</sub> did not affect the bactericidal effect of HHP treatment on *S. aureus*. Next, the effect of NaHCO<sub>3</sub> on *S. aureus* during incubation after HHP treatment was examined. At 37°C, although the growth of bacteria was inhibited depending on the concentration of NaHCO<sub>3</sub> in the early stages of incubation, the bacterial populations finally reached the same level as those without NaHCO<sub>3</sub> or HHP treatment. On the other hand, the number of bacteria decreased during the incubation at 10°C, and finally decreased to almost the detection limit with the addition of 0.4-0.7 M NaHCO<sub>3</sub> after incubation. The number of bacteria after HHP treatment at 600 MPa tended to decrease more than at 400 MPa, but it increased during incubation at all NaHCO<sub>3</sub> concentrations due to different HHP treatment times at 400 and 600 MPa.

In beef samples, the number of bacteria after HHP treatment was slightly less than those without HHP treatment. NaHCO<sub>3</sub> did not affect the bacterial number of *S. aureus* during HHP treatment as well as BHI broth. The bacterial number in beef with HHP treatment during storage was lower than that without HHP treatment regardless of NaHCO<sub>3</sub> concentrations.

From these results, it is suggested that NaHCO<sub>3</sub> was effective in the inhibition of the growth of *S. aureus* under a low temperature condition for a long period of storage after HHP treatment, although it did not affect the bactericidal effect of HHP treatment on *S. aureus*.

**Key words:** *Staphylococcus aureus*, High hydrostatic pressure (HHP), Sodium bicarbonate