

# Thermal resistance and chlorine tolerance of foodborne pathogens pre-exposed to heat, acid and osmotic stresses

Thamiris Maciel Machado<sup>1</sup>, Larissa da Costa Teodoro<sup>1</sup>, Mirian Pereira Rodarte<sup>1</sup>,  
Brenda Neres Targino<sup>2</sup>, Humberto Moreira Húngaro<sup>1\*</sup>

<sup>1</sup> Faculty of Pharmacy, Juiz de Fora Federal University, Campus Universitário, Rua José Lourenço Kelmer, s/n - São Pedro, Juiz de Fora - MG, 36036-900

<sup>2</sup> Department of Nutrition, Institute and Biological Sciences, Juiz de Fora Federal University, Campus Universitário, Rua José Lourenço Kelmer, s/n - São Pedro, Juiz de Fora - MG, 36036-900

\* Corresponding author. E-mail: [humberto.hungaro@farmacia.ufjf.br](mailto:humberto.hungaro@farmacia.ufjf.br)

Foodborne pathogens are responsible for thousands of illnesses worldwide and pose a public health issue. These microorganisms can adapt to sublethal stress conditions commonly encountered in the food processing environment, which in turn affects the effectiveness of the inactivation methods used in the food industry. In this study, the effect of pre-exposure to heat, acid, and osmotic stresses on the thermal resistance and chlorine tolerance of *Staphylococcus aureus*, *Salmonella* Enteritidis, and *Listeria monocytogenes* was evaluated. Bacteria were grown in BHI for 24 h under heat (45 °C, 0% sucrose, pH 7.0), acid (37 °C, 0% sucrose, pH 5.0), osmotic (37 °C, 20% sucrose, pH 7.0) stresses, and a control condition (37 °C, 0% sucrose, pH 7.0). Subsequently, they were subjected to thermal treatment (55 °C for 5 min) and disinfection (10 ppm free chlorine for 1 min). The counts of survivors were determined on BHI agar using drop plate method and optimal growth conditions for each pathogen. Both thermal resistance and chlorine tolerance were strain-dependent and influenced by the type of stress to which the pathogen was pre-exposed. *S. Enteritidis*, *L. monocytogenes*, and *S. aureus*, when not exposed to stress, exhibited reductions in counts of 1.5, 2.6, and 0.7 log CFU/mL upon chlorine disinfection, and 1.1, 1.2, and 0.7 log CFU/mL after thermal treatment, respectively. Lower reductions in survivor counts after chlorine disinfection were observed when *S. Enteritidis* was pre-exposed to osmotic and thermal stresses, and when *L. monocytogenes* was pre-exposed to acid and thermal stresses. On the other hand, the pre-exposure of *S. aureus* to stresses did not affect chlorine tolerance of this bacterium. Regarding thermal resistance, the count of *S. Enteritidis* after thermal treatment, for both those pre-exposed to acid and heat stresses, did not exhibit statistically significant differences ( $p > 0.05$ ) when compared to the counts of cells not exposed to stresses. However, preexposure of *S. Enteritidis* to osmotic stress reduced its thermal resistance. On the other hand, the pre-exposure of *L. monocytogenes* to stresses did not affect the thermal resistance of this bacterium. Counts of *S. aureus* after thermal treatment showed lower reductions when cells were pre-exposed to osmotic and acid stresses compared to the counts of cells not exposed to stresses. Our findings suggest that pre-exposure to stress influences the inactivation of foodborne pathogens by chemical and physical methods, depending on intrinsic characteristics of the strains as well as the type of sublethal stress applied.

**Key words:** Adaptation to stress; foodborne pathogen; disinfection; thermal treatment.

**Resistência térmica e tolerância ao cloro de patógenos de origem alimentar pré-expostos ao estresse térmico, ácido e osmótico**

Patógenos de origem alimentar representam um problema de saúde pública. Estes microrganismos podem adaptar-se a condições de estresse subletal encontradas no processamento de alimentos, o que pode afetar a eficácia dos métodos de inativação. O objetivo do estudo foi avaliar o efeito da exposição ao estresse térmico, ácido e osmótico na resistência térmica e tolerância ao cloro de *Salmonella* Enteritidis, *Listeria monocytogenes* e *Staphylococcus aureus*. Os resultados demonstraram que a pré-exposição ao estresse influencia a inativação de patógenos de origem alimentar por métodos químicos e físicos, dependendo das características intrínsecas das cepas e do tipo de estresse subletal aplicado.

**Palavras-chave:** Adaptação ao estresse; patógenos de origem alimentar; desinfecção; tratamento térmico.