Staphylococcus aureus in dry-cured ham: a predictive model covering aw, packaging and storage temperature

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Introduction: The potential risk associated with Staphylococcus aureus growth and enterotoxin (SE) production in sliced dry-cured ham (DCH) is controlled by key hurdles such as a_w, pH and temperature. As halotolerant bacteria, S. aureus is able to grow over much adverse conditions than other pathogens, being the 0.83 the minimum a_w (ANSES, 2011). According to available predictive models for S. aureus, the physico-chemical characteristics of commercialized DCH are associated with a probability of growth higher than 90% at temperature above 15ºC. In this framework, the main objective of the study was to experimentally quantify the behavior of S. aureus as a function of storage temperature and a_w for different packaging conditions.

Materials and methods: Selected DCH with different a_w (0.861-0.925) were sliced, packaged under 3 formats (aerobically, modified atmosphere (MAP, 80:20 N2:CO2) and vacuum) and stored at different temperatures (2 - 25 ºC) up to 1 year. Samples were inoculated (at 2 – 6 log CFU/g, depending on the conditions) with a cocktail of 3 strains of S. aureus (CECT4466, CECT976 and CTC1008). The pathogen and lactic acid bacteria were enumerated and temperature, pH and a_w were monitored along the storage. Changes in the pathogen levels were calculated as $\log_{10}$ increase or $\log_{10}$ reductions from $\log_{10}$ cfu/g. The Logistic growth model and the Weibull model were fitted to data to estimate the primary kinetic parameters for the pathogen growth and inactivation, respectively. The influence of a_w and storage temperature on the kinetic parameters was quantified through polynomial models. Finally, secondary polynomial models were integrated into the primary models to obtain a global model about the behavior of S. aureus in DCH along the storage as a function of a_w and temperature.

Results: Behavior of S. aureus was dependent on the storage temperature, product a_w and packaging type. Under aerobic conditions, growth was observed only for DCH with the highest a_w, increasing up to 2.7 and 4.54 $\log_{10}$ units in 1.7 and 4.7 days at 20 and 25 ºC, respectively. However, the formation of SE was not detected for any these samples. Also, vacuum and MAP packaging compromised the pathogen viability in all DCH irrespectively of the product's a_w and the storage temperature. Under conditions not supporting growth, the delta parameter (δ, time for the first $\log_{10}$ reduction) was only statistically dependent on the storage temperature, while the shape parameter could be fixed to a common value for all conditions in each packaging type. Compared to what was observed for other pathogens such as Listeria monocytogenes (Serra-Castelló et al., 2020) and Salmonella spp. (Serra-Castelló et al., 2021) in dry-cured meat products, δ values were much longer (from 40 days to more than 1 year) and DCH's a_w did not significantly affect S. aureus inactivation kinetics, which could be attributed to the halotolerance of this microorganism.

Conclusion: The challenge test results and the mathematical model developed can be used by the DCH producers to assess the risk associated with S. aureus on their products and take decisions on the suitability to commercialize them without refrigeration.

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