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Behaviour of Listeria monocytogenes on sliced cooked ham subjected to fluctuating temperatures

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Introduction

Storing food at home is a critical stage in the food chain, as consumers' mispractices can increase the risk of food poisoning.

Food Safety Authorities recommendation on the maximum operating temperature of the domestic refrigerators differ slightly. Food and Drug Administration (FDA) recommends a maximum storage temperature of 4 ℃, while the European Food Safety Authority (EFSA) and national food safety authorities advise consumers to keep their food at less than 5 ℃. The difference between these messages might be confusing for consumers.

This study aimed to evaluate the growth of *L. monocytogenes* on a ready-to-eat (RTE) ham subjected to refrigeration temperatures generally applied by consumers for food storage at home.

Methodology

Ham samples were placed in sterile Petri dishes and contaminated with *L. monocytogenes* at either medium (10^2 - 10^3 CFU/g) or high (10^4 - 10^5 CFU/g) final concentration.

Scenarios:

I. Samples were stored at 4, 5, and 7 ℃ for 5 days

II. Samples were stoder at 25 ℃ / 2 h - 5 or 7 ℃ / 22 h - 25 ℃ / 1 h - 5 or 7 ℃ / 23 h - 25 ℃ / 1 h - 5 or 7 ℃ / 23 h - 25 ℃ / 1 h

Temperature was monitored and recorded every 5 min with data loggers (RC5-USB accuracy of measurement: ± 0.5 °C; Elitech, London, UK).

Barany and Roberts model (Eqs. (1) and (2)):

$$F(t) = t + \frac{1}{v}\ln(e^{-vt} + e^{-\mu_{max}\lambda} + e^{-vt-\mu_{max}\lambda}) \quad (1)$$

$$y(t) = y_0 + \mu_{max}F(t) - \ln\left(1 + \frac{e^{\mu_{max}F(t)}}{e^{y_{max}-y_0}}\right) \quad (2)$$

The lag phase duration (λ, h), maximum growth rate (μ_{max}, $\log_{10}$ CFU/h), and maximum bacterial population (y_{max}, $\log_{10}$ CFU/g) was estimated using nonlinear regression (SAS 9.1). The limiting substrate's rate of increase, v, was assumed to be equal to μ_{max} while y_0 and $y(t)$ are the *L. monocytogenes* cells' concentrations in $\log_{10}$ CFU/g at 0 and t (h).
Stochastic evaluation during dynamic storage was made using Monte Carlo simulation.

Results

Overall, regardless of the temperature at which it was stored, the RTE ham supported the growth of *L. monocytogenes*, with a growth potential (the difference between the final and the initial concentration), at the end of the 5 days, higher than 0.5 $\log_{10}$ CFU/g. The increase was sustained by the favorable proliferation conditions provided by ham, meaning that, if improperly stored, the meat product has the potential of causing foodborne illnesses in humans.

Barany and Roberts model was able to describe *L. monocytogenes* in the first and second scenario.

In contrast with constant storage at 5 ℃ of the RTE ham contaminated with *L. monocytogenes* at a medium and high concentration for 72 h (scenario I), the application of the variable temperature scenario (II) within which the contaminated ham, kept at 5 ℃, was exposed occasionally to ambient temperature , determined a significantly higher ability of the pathogen to grow ($p < 0.05$). In this case, the differences regarding *L. monocytogenes* growth were 0.34 and 0.51 $\log_{10}$ CFU/g, respectively.

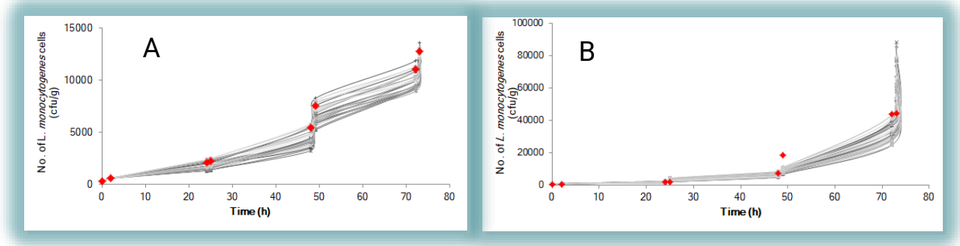

Figure 1. Simulations of *L. monocytogenes* growth curves in ham using Baranyi and Roberts model in dynamic storage conditions at: A) 5 °C and B) 7 °C using Monte Carlo experiments (30 repetitions) and the determined numbers of cells (♦)

In the domestic environment, refrigerated storage of RTEs could involve several actions of taking food out from the fridge for one or couple of times, leaving it a limited time at environmental temperature and then placing it back in the fridge. These short storage intermezzos at environmental temperature influence the kinetics of *L. monocytogenes* growth (Figure 1).
The stochastic model better described the *L. monocytogenes* growth in the 2nd scenario at 5 °C than at 7 °C , however we can consider all the experimental values in the prediction-horizon of the stochastic model applied.

Conclusions

To be able to stay on the safe side, consumers have to be informed and have the governments' support in replacing old fridges with new ones, in which temperature fluctuations are of low amplitude.

The Baranyi and Roberts model of growth and the kinetic parameters describing temperature dependence could be applied in stochastic models that include temperature fluctuations, allowing simulations of *L. monocytogenes* growth..

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