Expanded cardinal parameter model with terms for phosphate salts to predict growth of Listeria monocytogenes in spreadable cheeses

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Absence of *L. monocytogenes* growth in ready-to-eat foods at the consumer phase is estimated to reduce listeriosis cases per year by 37% (EFSA, 16, 1-173, 2018). Spreadable cheeses are ready-to-eat foods with products characteristics including pH of 5.6-6.4 and NaCl of 0.7-1.6% w/w that may support growth of *L. monocytogenes* if contaminated by consumers after opening of packed products that are typically hot filled. To reduce growth of *L. monocytogenes* in spreadable cheeses at the consumer phase recipes and the content of phosphate salts is important. These salts are known to inhibit growth of some microorganisms; however, their anti-listerial effect remains little studied. Product reformulation and recipe optimization can be assisted by challenge testing but the use of validated predictive models is faster and more cost effective. The objective was to develop and validate an extensive model to predict growth of *L. monocytogenes* in spreadable cheese containing phosphate salts.

The new model was developed by expanding an existing cardinal parameter-type model that included 12 environmental parameters (IJFM, 141, 137-150, 2010). MIC-values for orthophosphate, pyrophosphate and triphosphate salts were determined in broth and terms modelling their antimicrobial and interactive effects were added to the existing model. The new model has been evaluated; so far, under constant temperature using a total of 48 growth/no growth responses in well characterized spreadable cheeses. Average bias and accuracy factor values were 1.02 and 1.20 for 24 growth curves. The model predicted growth/no growth correctly for 87.5% of the responses with 12.5% being fail-safe. The new model can be used to facilitate product reformulation as shown here for spreadable cheese at 8 °C, pH 6.3, *a*<sub>W</sub> 0.972 and water phase organic acid concentrations of 0.8 % (lactic), 0.3 % (citric), 0.1 % (acetic) and phosphate salt of 1.9 % (orthophosphate). If this product is contaminated with 1-10 cfu/g by the consumer it will take 3-6 days for *L. monocytogenes* to reach the critical limit of 2 log cfu/g. However, by substituting the orthophosphate with 1.9% triphosphate the reformulated product prevents growth of *L. monocytogenes* from exceeding the critical limit for 11-22 days.

The high number of environmental factors included in the new model makes it a flexible tool to support product development where the anti-listerial effect of phosphate salt can be taken into account when recipes are optimized.