Impact of interventions during food production on microbial biodiversity

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A meta-regression model of the growth rate of *Listeria monocytogenes* as affected by temperature

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The presence of *L. monocytogenes* in naturally-contaminated foods, its ability to endure various environmental stresses and grow at low temperatures and during the shelf life of some foods are great challenges for the food industry. To overcome this issue, predictive models can be used on the decision-making process in case of presumed contamination and possible growth of pathogens as they can assess bacterial levels before a control step is applied and evaluate if the process allows the pathogen's inactivation or reduction to an acceptable level.

In this sense, Cardinal Parameters Models (CPM) have been widely used to describe the effect of environmental factors on microbial growth rates. To be used, the determination of the parameters, known as cardinal values, is needed, but since experimental estimation is a laborious task, it is proposed here that meta-analysis of literature data could be useful to perform such assessments. This statistical analysis of results from published studies aims to integrate and interpret the findings to achieve an enlarged vision about the topic's results.

Suitable scientific articles were collected through search in several databases. Following study quality checking, 88 studies remained from which 3079 growth rates were extracted.

To evaluate temperature's effect on growth rates and estimate comprehensive cardinal values, meta-analysis was performed on a set of growth rates assessed at optimal conditions of pH (6.5-8) and a_w (≥0.98). To appraise the share of the possible sources of variability, the CPM was also fitted on subsets of growth rates estimated using (i) distinct reading methods, (ii) distinct broth types and (iii) sub-optimal conditions of pH and a_w.

The pooled parameters from the optimal set were T_{min}=-1.15±2.43 °C, T_{opt}=37.42±2.00 °C, T_{max}=45.20±0.37 °C and μ_{opt}=1.06±0.13 h^{-1}. Regarding the possible sources of variability, it was concluded that the reading method (R^2=24.8%) and the broth type (R^2=60.1%) used to estimate growth rates largely affect the estimation of cardinal values. Moreover, data at sub-optimal conditions, especially in food products, were found inadequate to assess cardinal values, unlike optimal conditions, as mean estimates changed and standard errors increased.

The meta-analysis performed allowed the fitting of the CPM to growth rate data retrieved from scientific articles, showing that literature can be useful to assess cardinal values and to provide an insight on sources of variability.

Keywords: Meta-analysis, Cardinal Parameters Model, optimal conditions, broth