Application of Robust Statistical Optimal Designs for Growth Rate Models in Predictive Food Microbiology

Jean-Pierre Gauchi*
National Institute of Agronomic Research (INRA), France
jean-pierre.gauchi@jouy-inra.fr

Jean-Christophe Augustin
Veterinary School of Alfort, France
jcaugustin@vet-alfort.fr

Several statistical predictive models have been used in the food microbiology field in recent years to describe the growth or the inactivation of bacterial populations. These dynamic primary models (PMs) are nonlinear relative to their parameters. In addition, these parameters can themselves be modelled by nonlinear secondary models (SMs) as functions of environmental factors (EFs) such as temperature, pH, water activity, nitrites and phenol concentrations, etc. For example, the mumax parameter (representing the maximum growth rate of the PMs) can be modelled by several SMs. Typically, one class of SMs deals with the nonlinear interactions between the EFs, whereas the second does not. A major objective for the microbiology community is to select the model that will make the best predictions of pathogenic bacteria behaviour for the purpose of ensuring food safety. To make the best choice, these SMs, estimated using microbiological data, must provide accurate parameter and prediction estimations. However, it remains difficult to obtain adequately accurate estimates because of the high variability of microbiological data. Obviously, some optimal experiments must be conducted in order to reach this objective. In this paper, we propose an experimental strategy based on the use of some robust statistical optimal designs, followed by computer simulations, to compare the different designs. We propose two classes of well-known robust optimal designs: (i) the first class, derived from the D-optimality criterion, is based on a well-known criterion, the maximisation of the expectation of the log determinant of the Fisher information matrix; (ii) the second class is based, from the Bayesian point of view, on the minimisation of the expectation of an exact parametric confidence region. Until now, these types of designs, although already well defined and described in the literature, have never been used in the food microbiology field. We think that a significant improvement could be obtained in the model discrimination and in the predictive power of the SMs by using such efficient tools.

Key Words: D and X-optimal designs, Bayesian D and X-optimal designs, accurate parameter estimation, food safety.