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Effects of Temperature and the Use of Bacteriocins on Cross-Contamination from Animal Source Food Processing: A Mathematical Model

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Abstract : The contamination of food by microbial agents is a common problem in the industry, especially regarding the elaboration of animal source products. Incorrect manipulation of the machinery or on the raw materials can cause a decrease in production or an epidemiological outbreak due to intoxication. In order to improve food product quality, different methods have been used to reduce or, at least, to slow down the growth of the pathogens, especially deteriorated, infectious or toxigenic bacteria. These methods are usually carried out under low temperatures and short processing time (abiotic agents), along with the application of antibacterial substances, such as bacteriocins (biotic agents). This, in a controlled and efficient way that fulfills the purpose of bacterial control without damaging the final product. Therefore, the objective of the present study is to design a secondary mathematical model that allows the prediction of both the biotic and abiotic factor impact associated with animal source food processing. In order to accomplish this objective, the authors propose a three-dimensional differential equation model, whose components are: bacterial growth, release, production and artificial incorporation of bacteriocins and changes in pH levels of the medium. These three dimensions are constantly being influenced by the temperature of the medium. Secondly, this model adapts to an idealized situation of cross-contamination animal source food processing, with the study agents being both the animal product and the contact surface. Thirdly, the stochastic simulations and the parametric sensibility analysis are compared with referential data. The main results obtained from the analysis and simulations of the mathematical model were to discover that, although bacterial growth can be stopped in lower temperatures, even lower ones are needed to eradicate it. However, this can be not only expensive, but counterproductive as well in terms of the quality of the raw materials and, on the other hand, higher temperatures accelerate bacterial growth. In other aspects, the use and efficiency of bacteriocins are an effective alternative in the short and medium terms. Moreover, an indicator of bacterial growth is a low-level pH, since lots of deteriorating bacteria are lactic acids. Lastly, the processing times are a secondary agent of concern when the rest of the aforementioned agents are under control. Our main conclusion is that when acclimating a mathematical model within the context of the industrial process, it can generate new tools that predict bacterial contamination, the impact of bacterial inhibition, and processing method times. In addition, the mathematical modeling proposed logistic input of broad application, which can be replicated on non-meat food products, other pathogens or even on contamination by crossed contact of allergen foods.

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