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Mathematical Modelling of Bacterial Growth in Products of Animal Origin in Storage and Transport: Effects of Temperature, Use of Bacteriocins and pH Level

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Abstract : The pathogen growth in animal source foods is a common problem in the food industry, causing monetary losses due to the spoiling of products or food intoxication outbreaks in the community. In this sense, the quality of the product is reflected by the population of deteriorating agents present in it, which are mainly bacteria. The factors which are likely associated with freshness in animal source foods are temperature and processing, storage, and transport times. However, the level of deterioration of products depends, in turn, on the characteristics of the bacterial population, causing the decomposition or spoiling, such as pH level and toxins. Knowing the growth dynamics of the agents that are involved in product contamination allows the monitoring for more efficient processing. This means better quality and reasonable costs, along with a better estimation of necessary time and temperature intervals for transport and storage in order to preserve product quality. The objective of this project is to design a secondary model that allows measuring the impact on temperature bacterial growth and the competition for pH adequacy and release of bacteriocins in order to describe such phenomenon and, thus, estimate food product half-life with the least possible risk of deterioration or spoiling. In order to achieve this objective, the authors propose an analysis of a three-dimensional ordinary differential which includes; logistic bacterial growth extended by the inhibitory action of bacteriocins including the effect of the medium pH; change in the medium pH levels through an adaptation of the Luedeking-Piret kinetic model; Bacteriocin concentration modeled similarly to pH levels. These three dimensions are being influenced by the temperature at all times. Then, this differential system is expanded, taking into consideration the variable temperature and the concentration of pulsed bacteriocins, which represent characteristics inherent of the modeling, such as transport and storage, as well as the incorporation of substances that inhibit bacterial growth. The main results lead to the fact that temperature changes in an early stage of transport increased the bacterial population significantly more than if it had increased during the final stage. On the other hand, the incorporation of bacteriocins, as in other investigations, proved to be efficient in the short and medium-term since, although the population of bacteria decreased, once the bacteriocins were depleted or degraded over time, the bacteria eventually returned to their regular growth rate. The efficacy of the bacteriocins at low temperatures decreased slightly, which equates with the fact that their natural degradation rate also decreased. In summary, the implementation of the mathematical model allowed the simulation of a set of possible bacteria present in animal based products, along with their properties, in various transport and storage situations, which led us to state that for inhibiting bacterial growth, the optimum is complementary low constant temperatures and the initial use of bacteriocins.

Keywords : bacterial growth, bacteriocins, mathematical modelling, temperature
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