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Prediction of the Staphylococcal Growth and Enterotoxin A Production in Minas Frescal Cheese Conditions

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Predictive microbiology is a powerful tool for food safety and quality. Using mathematical models, it is possible to predict the behavior of microorganisms under specific conditions. Given that Staphylococcus aureus is one of the pathogens most involved in food outbreaks and Minas frescal cheese is strongly associated with S. aureus, mathematical models are relevant to demonstrate how bacterial growth and enterotoxins production are influenced by production and storage conditions. Polynomial and probabilistic logistic regression models were adjusted to investigate the effect of temperature (10, 15 and 25 °C), pH (5.3, 5.5, 6.0, 6.5 and 6.7), NaCl (0.8, 1.0, 1.5, 2.0 and 2.2%), inoculum concentration (1, 3 and 5 log CFU/mL) on the S. aureus growth and production of enterotoxin A (SEA) production, respectively. Colonies were counted and SEA production was assessed at 24 h intervals for up to 240 h. The growth and production of SEA by S. aureus were influenced by all factors, except NaCl concentration. S. aureus produced SEA in all samples at 25 °C (Counts of 8.27 to 9.36 log CFU/mL), while at 15 °C (Counts of 3.90 to 8.27 log CFU/mL), the production occurred in all conditions at 144 h. Temperature of 10 °C (Counts of <1.0 CFU/mL to 7.79 CFU/mL) delayed the growth of S. aureus and SEA production at initial contamination levels of 3 log CFU/mL and 5 log CFU/mL, and prevent it at 1 log CFU/mL. The models were statistically and experimentally validated, demonstrating a good fit, with satisfactory values for R^2 (0.90), accuracy factor (1.09), and bias factor (0.99) for the growth model; a high agreement percentage (94.4%), Nagelkerke's R^2 (0.92), and the Hosmer and Lemeshow test ($p > 0.05$) for the SEA production model. For the experimental validation in growth model, bias factor values of 1.12, 0.85, and 0.80, as well as accuracy factor values of 1.22, 1.19, and 1.08, were observed for the responses in BHI, milk, and cheese, respectively and, for the enterotoxin model, 88% were correctly classified by the model in BHI and 78% and 83% in UHT milk and Minas fresh cheese, respectively. The experimental validation confirmed the effectiveness of the models in predicting the growth and the SEA probability production by S. aureus under conditions of production and storage of Minas frescal cheese. New models should be proposed to assess the influence of these factors on the concentration of SEA produced by S. aureus.

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