Title Modeling the effect of temperature on the growth rate and lag phase of *Penicillium expansum* in apples

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Citation International Journal of Food Microbiology, Volume 118, Issue 2, 15 September 2007, Pages 139-150

Keywords Apple; *Penicillium expansum*; Model; Growth rate; Lag phase; Validation; Simulation medium

Abstract

The objective of the present study was to develop validated models that describe the effect of storage temperature on the growth rate and lag phase of six *Penicillium expansum* strains. The growth of the selected strains was therefore studied on Apple Puree Agar Medium (APAM) at 30, 25, 16, 10, 4 and 2 °C. Growth rates and lag phases were estimated using linear regression. Several secondary models were evaluated and for the growth rate, a modification of the extended Ratkowsky model was selected. Regarding the lag phase, the Arrhenius–Davey model provided the best adjustment to the observed data. Model validation was performed in two steps. Firstly, the developed models were validated on APAM. The obtained bias factors (B_f) ranged from 0.91 to 1.14 and the accuracy factors (A_f) were < 1.2 for the validation performed on APAM, indicating that the models were good predictors of the true mean colony growth rate and lag phase. Afterwards, an external validation was carried out in apples. For the growth rate, B_f ranged from 0.64 to 0.81 and $A_f < 1.39$, indicating conservative predictions. On the contrary for the lag phase, a clear deviation was observed between predictions and observed values on apples ($0.35 < B_f < 0.7$ and $A_f > 1.6$). These results highlight that the use of simulation or synthetic media for the development of predictive models for the lag phase of moulds can lead to inadequate predictions and that a validation on the real food matrix is necessary. Application of the developed models is possible in the framework of Quantitative Risk Assessment to develop control strategies against blue mould rot in apple and enables the inclusion of strain variability. However, possible underestimation of the lag phase should be taken into account.