



Quantifying the effect of water activity and storage temperature on single spore lag times of three moulds isolated from spoiled bakery products



Stéphane Dagnas^a, Maria Gougouli^{b,c}, Bernard Onno^a,
Konstantinos P. Koutsoumanis^b, Jeanne-Marie Membré^{d,a,*}

^a L'Université Nantes Angers Le Mans, Oniris, Nantes F-44322 cedex 3, France

^b Laboratory of Food Microbiology and Hygiene, Department of Food Science and Technology, School of Agriculture, Aristotle University of Thessaloniki, Thessaloniki 54124, Greece

^c Department of Food Science and Technology, Perrotis College, American Farm School, Thessaloniki 55102, Greece

^d UMR1014 SECALIM, INRA, Oniris, 44307 Nantes, France

ARTICLE INFO

Article history:

Received 21 January 2016

Received in revised form 27 May 2016

Accepted 11 June 2016

Available online 14 June 2016

Keywords:

Individual lag time

Single spore

Biological variability

Predictive microbiology

ABSTRACT

The inhibitory effect of water activity (a_w) and storage temperature on single spore lag times of *Aspergillus niger*, *Eurotium repens* (*Aspergillus pseudoglaucus*) and *Penicillium corylophilum* strains isolated from spoiled bakery products, was quantified. A full factorial design was set up for each strain. Data were collected at levels of a_w varying from 0.80 to 0.98 and temperature from 15 to 35 °C. Experiments were performed on malt agar, at pH 5.5. When growth was observed, ca 20 individual growth kinetics per condition were recorded up to 35 days. Radius of the colony vs time was then fitted with the Buchanan primary model. For each experimental condition, a lag time variability was observed, it was characterized by its mean, standard deviation (sd) and 5th percentile, after a Normal distribution fit. As the environmental conditions became stressful (e.g. storage temperature and a_w lower), mean and sd of single spore lag time distribution increased, indicating longer lag times and higher variability. The relationship between mean and sd followed a monotonous but not linear pattern, identical whatever the species. Next, secondary models were deployed to estimate the cardinal values (minimal, optimal and maximal temperatures, minimal water activity where no growth is observed anymore) for the three species. That enabled to confirm the observation made based on raw data analysis: concerning the temperature effect, *A. niger* behaviour was significantly different from *E. repens* and *P. corylophilum*: T_{opt} of 37.4 °C (standard deviation 1.4 °C) instead of 27.1 °C (1.4 °C) and 25.2 °C (1.2 °C), respectively. Concerning the a_w effect, from the three mould species, *E. repens* was the species able to grow at the lowest a_w ($a_{w,min}$ estimated to 0.74 (0.02)). Finally, results obtained with single spores were compared to findings from a previous study carried out at the population level (Dagnas et al., 2014). For short lag times (≤ 5 days), there was no difference between lag time of the population (ca 2000 spores inoculated in one spot) and mean (nor 5th percentile) of single spore lag time distribution. In contrast, when lag time was longer, i.e. under more stressful conditions, there was a discrepancy between individual and population lag times (population lag times shorter than 5th percentiles of single spore lag time distribution), confirming a stochastic process. Finally, the temperature cardinal values estimated with single spores were found to be similar to those obtained at the population level, whatever the species. All these findings will be used to describe better mould spore lag time variability and then to predict more accurately bakery product shelf-life.