Modeling red cabbage seed extract effect on *Penicillium corylophum*:
Relationship between germination time, individual and population lag time

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**Abstract**

The inhibitory effect of red cabbage seed extract on germination time, individual (single spore) and population lag time of *Penicillium corylophum* was studied. First, to compare the biological variability of single spore germination and lag times under stressful conditions, data were collected at levels of red cabbage seed extract varying from 0 to 10 mg/g (150 spores observed in each trial of germination, ca 50 spores in each individual lag experiment). Experiments were performed on malt agar at 25 °C, pH 5.2, aw 0.99. The data, without any transformation, were statistically analyzed; several probability distribution functions were used to fit the cumulated germination times and the individual lag times of spores. In both cases, the best fit was obtained with the Normal distribution. In parallel, lag times at the population level (ca 2000 spores per trial) were collected for the same range of plant extract. Not surprisingly, the difference between individual and population lag times could be explained by a stochastic process. More interestingly, it was shown that under stressful conditions, the population lag time did not correspond to the time required for germination of 95% of spores, but to a much longer time. Finally, it was deduced from the statistical analysis, completed by microscopic observations, that the plant extract affected mainly the hyphal elongation (and then the lag time) and not the germination. Next, secondary models were developed to quantify the effect of red cabbage seed extract on the median of germination times, individual and population lag times. The Minimum Inhibitory Concentrations (MICs) were estimated. It was shown that the red cabbage seed extract MIC for *P. corylophum* lag time did not depend on the inoculum load. Application of the secondary models allowed us to conclude that under the conditions of our experiment, the addition of 10 mg/g of red cabbage seed extract enabled extension of lag time to two weeks.

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