The use of flow cytometry and particle size analysis in the individual-based model INDISIM-YEAST, a simulator of yeast populations

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INTRODUCTION

The sizes and growth rates of individual cells to simulate Saccharomyces cerevisiae culture, are highly heterogeneous, mostly due to the asymmetric cell division of budding yeast and to aging.

Flow cytometry and particle size analysis by electric sensors are valuable and advanced tools that combine direct and rapid assays to determine numbers, cell size distributions and even biochemical and physiological characteristics of individual cells (Vives-Regó et al., 2000). Experimental data obtained by flow cytometry and particle analyzer of the temporal evolutions of the S. cerevisiae populations in batch cultures are used to determine the effective growth conditions.

The growth of Saccharomyces sp. under batch conditions was modeled using INDISIM-YEAST, an individual-based simulator (Ginovart et al., 2002, 2007). The analysis and interpretation of this kind of experimental data and the preliminary simulated results correspond to the stage after the exponential growth of the aerobic culture, from the slow down metabolic period to the stationary phase, will contribute to the development of INDISIM-YEAST.

The combination of flow cytometry, particle analysis and an individual-based model in our hands is established as an opportunity to deal with the study of yeast populations dynamics.

INDISIM (INdividual DIscrite Simulations) is a model that stands on an individual-based methodology to study microbial systems.

INDISIM-YEAST is an adaptation from INDISIM to study yeast populations in batch cultures.

RESULTS AND DISCUSSION

Figure 1: Yeast population model

- The set of (i) yeast cells confined the population, defined by:
  \[
  N(t) = \sum_{i=1}^{N(t)} n_i \cdot t
  \]
- Where:
  \[
  n_i = \begin{cases}
  1 & \text{if cell } i \text{ is alive} \\
  0 & \text{otherwise}
  \end{cases}
  \]
- Each cell has a specific location and size in the physiological state, and its growth is driven by the metabolic requirements.

Figure 2: Yeast population growth

- The population growth is exponential, described by the equation:
  \[
  N(t) = N_0 \cdot e^{rt}
  \]
- Where:
  \[
  N_0 \quad \text{(initial population)} \\
  r \quad \text{(growth rate)} \\
  t \quad \text{(time)}
  \]

Figure 3: Yeast cell replication

- The cell cycle involves two phases: the unbudded phase and the budding phase.
- The budding phase is characterized by the synthesis of new cell membrane and the formation of a bud, which will give rise to a new cell.

Figure 4: Yeast cell size

- The yeast cell size is determined by the cell membrane and the cytoplasm.
- The size distribution is bell-shaped, with a peak at the mean size and a spread determined by the standard deviation.

REFERENCES


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