MULTIPHYSICAL SIMULATION OF HYDRODYNAMIC TRAPPING OF *S.cerevisiae*

I.M.Acosta[1 2], D.C.Duran[2], J.M.Pedraza[2]

1. Laboratorio de Biofísica, Departamento de Física, Universidad de los Andes, Bogotá - Colombia

2. Universidad Distrital Francisco José de Caldas, Bogotá – Colombia

INTRODUCTION: Saccharomyces cerevisiae yeast is a model organism used for the study of aging in eukaryotic cells. The traditional method with which aging is studied uses micromanipulators, which makes it difficult, because great precision is required in the construction of these devices, causing it to consume a lot of time and at the same time many resources. The use of micromanipulators and the mechanical pressure they exert on the cell can affect its physiology (growth rate, genetic expression, aging, etc.), which would bias the results of these experiments. As an alternative, we propose a microfluidic platform that does not use mechanical but hydrodynamic trapping. This device must achieve the objective of trapping the mother cell, taking advantage of the slipstreaming effect, to let the daughter cells escape, requiring a very precise adjustment of the flows. To design this device, multiphysics simulations were carried out in order to test different parameters and select the optimal ones. In this work, we present the results of these simulations and their experimental application for the development of a platform that automates aging measurements in yeasts.

COMPUTATIONAL METHODS: The slipstreaming effect was modeled by numerically solving the Navier-stokes equations, by the finite element method in COMSOL Multiphysics. This being a numerical method which consists of the approximation of solutions to complex partial differential equations.

$$\boldsymbol{\rho}(\mathrm{u}\cdot\nabla)\mathrm{u}=\nabla\cdot[-\mathrm{pI}+\mu(\nabla\mathrm{u}+(\nabla u)^{T}]+F\boldsymbol{\rho}\nabla\cdot(\mathrm{u})=0$$

Where $\boldsymbol{\rho}$ is the density, u is the speed, μ is the viscosity, F is the strength of the body, ∇ is the gradient and p is the pressure

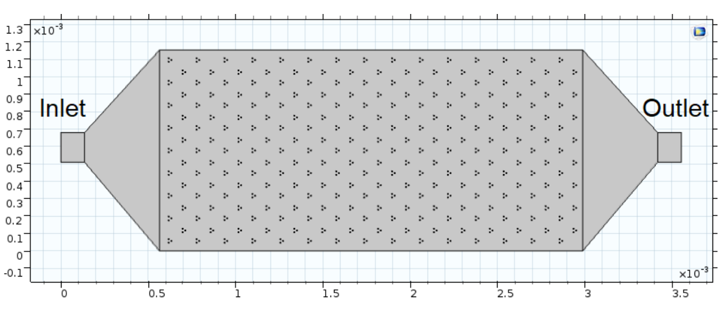

Figure 1: Geometry of the Mother machine channel.

RESULTS:

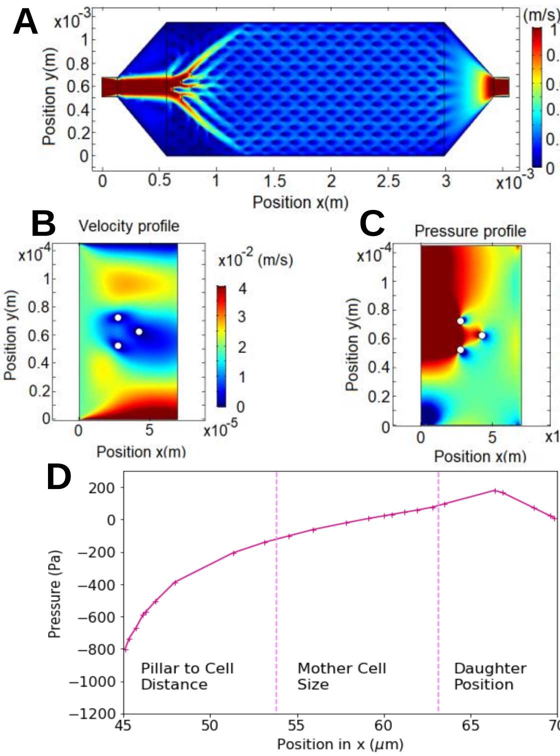

Figure 2. Finite element simulation using COMSOL Multiphysics **A.** The image shows a mother machine channel, where it has an input (left) and an output (right) and within it 30 columns divided into 15 of 9 rows and 15 of 8 rows for a total of 255 traps; This in turn shows the speed profile of the channel and from there the average speed and the limit conditions for each trap are obtained. **B**. The surface shows the magnitude of the fluid velocity, it can be seen that there is a low velocity zone to the right of the trap. **C.** The surface shows the pressure, a low pressure zone can be seen to the right of the trap. **D.** The surface shows the typical pressure profile for a trap. Trapped mother cells can be observed due to the action of a force to the left and the daughter cells separate due to a force to the right. The left section represents the distance from the pillar to the mother cell. The center section shows the capture area of the mother cell and its approximate size. The right section shows the region where the daughter cells are. [1]

CONCLUSIONS: The flow profile in the complete channel was obtained, which was very useful since it allowed obtaining the average velocity data for a more detailed analysis in each individual trap. It was observed that in the traps there is a pressure profile that allows to trap the mother cell and separate the daughter cell, taking advantage of its shape and its arrangement in the channel, in addition to the slipstreaming effect generated by the direction of flow and the same. The results obtained from the simulation conform to the experiment carried out. Evidence of the effectiveness and usefulness of this type of simulation, since they allow anticipating the behavior of the real experiment, being safer the course that it will take, in addition to avoiding problems in its development and unnecessary losses of the budget.

REFERENCES:

[1] Durán, D.C., Hernández, C.A., Acosta, I. M., Suesca, E., Acevedo, R., Forero, D., Rozo, F. S, Pedraza, J.M. (2020). Slipstreaming Mother Machine: A microfluidic device for single-cell dynamic imaging of yeast. Review.