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Two-layers cell-wall modelling for S. cerevisiae yeasts

Zeinab Awada[1]*, Etienne Harté[2], Françoise Argoul[2], Léo Delmarre[2], Pierre Argoul[1], Anne Devin[3] and Boumediene Nedjar[1]

[1] Université Gustave Eiffel, MAST/EMGCU, 5 Boulevard Descartes, 77454 Marne-la-Vallée cedex 2, France, zeinab.awada@univ-eiffel.fr
[2] Université de Bordeaux, LOMA, 351 Cours de la Libération, 33405 Talence, France
[3] Université de Bordeaux, IBGC, 1 rue Camille Saint Saëns, 33077 Bordeaux, France

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From human prehistory to present days, *Saccharomyces cerevisiae* yeasts exist in a wide range of daily use products. Biological studies on this kind of cells have provided a well-developped knowledge of its genetics and molecular properties. On another hand, the investigations on the mechanical properties were limited until only recently. For instance, experimental analyses show that the elastic modulus reported from the whole cell compression by micromanipulation is two orders of magnitude greater than that obtained using atomic force microscopy (AFM), e.g. [1, 2]. Here we assume that the difference is due to the heterogeneous nature of the cell-wall made of components with sensitively different mechanical properties. The cell-wall is represented as a two-layers material; a soft outer layer mainly made of components with low mechanical properties identified by nanoindentation and a stiffer inner one where characteristics of the components are obtained from micromanipulation.

Based on the Reissner-Mindlin's shell kinematics, a viscoelastic model is developped. The finite strain range is adopted because of the soft nature of the cells. The deformation gradient is multiplicatively split into an elastically relaxing and a viscous parts. Furthermore, the incompressible inner fluid of the closed cell is taken into account using follower loads the magnitude of which is continuously controled with the help of an Uzawa-like algorithm. In addition to the theoretical approach, a nanoindentation and micromanipulation test campaign is carried out on yeasts issued from the same culture with various speeds of loading. A mechanical interpretation is given to identify the viscoelastic properties of each layer and shows that these two techniques are complementary for a better characterization of the cell-wall. Within the finite element analysis, numerical simulations with the identified parameters show the time-dependent response of the whole cell.

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