



Cell-wall mechanical properties of *Saccharomyces cerevisiae*

by

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'Life has a range of magnitude narrow indeed compared to that with which physical science deals; but it is wide enough to include three such discrepant conditions as those in which a man, an insect and a bacillus have their being and play their several roles. Man is ruled by gravitation, and rests on mother earth. A water-beetle finds the surface of a pool a matter of life and death, a perilous entanglement or an indispensable support. In a third world, where the bacillus lives, gravitation is forgotten, and the viscosity of the liquid, the resistance defined by Stoke's law, the molecular shocks of Brownian movement, doubtless also the electric charges of the ionised medium, make up the physical environment and have their potent and immediate influence on the organism. The predominant factors are no longer those of our scale; we have come to the edge of a world of which we have no experience, and where all our preconceptions must be recast.'

Sir D'Arcy Wentworth Thompson

On Growth and Form,

2nd Edition, 1942, pp77.

Summary

Prediction of cell breakage in bioprocessing at the fundamental level of fluid-cell interactions is limited by the lack of measurements on the cell-wall mechanical properties. A suitable approach has not been developed to determine the fundamental cell-wall mechanical properties of single biological cells.

This thesis develops a suitable approach by combining the single-cell compression experiment with a mechanical model to determine the cell-wall mechanical properties of the yeast *Saccharomyces cerevisiae*.

A novel mechanical model is developed with finite element techniques. This model describes the compression of a liquid-filled inflated-sphere between two parallel surfaces where the walls are taken to be permeable. A parametric study conducted with this model determines dimensionless parameters that must be measured in conjunction with the compression experiment to ensure unique solution for the cell-wall mechanical properties.

Experimental methods are developed to measure these dimensionless parameters. These measurements are performed in conjunction with compression experiments. Cell-wall mechanical properties are uniquely extracted from this data with the mechanical model. This approach is also applied to determine the cell-wall mechanical properties in exponential and stationary phase of a batch fermentation.

These measurements are highly significant as they are the first that can be coupled with the general equations of motion to predict cell-breakage at the fundamental level of fluid-cell interactions. They are also the first to quantify the changes in cell-wall mechanical properties that accompany changes in growth phase. Future work is required to relate the cell-wall mechanical properties to the underlying molecular components and their assembly in the cell wall.

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