The Impact of Abiotic Stress on Ribosome Heterogeneity and Cell Recovery in *Saccharomyces cerevisiae*: Analysis of Translational Activity and Morphology

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ABSTRACT

Ribosomes, as central translational complexes, have long been considered static and homogeneous structures. However, growing evidence suggests that their heterogeneity may play a key role in translation regulation. The aim of this doctoral dissertation was to investigate the adaptive mechanisms of Saccharomyces cerevisiae in response to mild abiotic stresses, with particular emphasis on ribosome heterogeneity (changes in ribosomal protein composition and differential incorporation of ribosomal protein paralogs into the ribosome under stress conditions) and single-cell morphology.

This study employed a wide range of analytical methods, including high-resolution mass spectrometry (LC-HRMS) for ribosomal composition analysis, polysome profiling for assessing translational activity, and high-resolution quantitative phase imaging (holotomography) for examining stress-induced morphological changes in yeast cells.

It was demonstrated that exposure of S. cerevisiae to heat shock, osmotic stress, high salt conditions, UV radiation, amino acid starvation, glucose starvation, hypoosmotic stress, hyperosmotic stress, high pH, and anaerobic conditions leads to dynamic changes in the stoichiometry of ribosomal proteins and differential incorporation of ribosomal protein paralogs into the ribosomes. The observed changes were stress-specific, suggesting that different ribosome variants may preferentially participate in the translation of specific mRNAs.

Polysome profiling revealed that most stress conditions resulted in a global decrease in translational activity, with the exception of heat shock, which increased the proportion of polysomes, indicating enhanced translation activity at elevated temperatures. Additionally, holotomographic analysis enabled a detailed examination of morphological changes in yeast cells in response to stress, revealing reduced budding capacity and adaptive reorganization of cellular structure. Changes were observed in cell volume and shape, vacuole size and number, as well as protein and lipid content.

The findings of this doctoral dissertation provide new evidence for the existence of translational adaptation mechanisms in response to stress and suggest that ribosome heterogeneity may play a crucial role in cellular stress responses. Moreover, stress-induced morphological changes may reflect dynamic metabolic and structural adjustments to environmental conditions, enhancing survival and adaptive potential. These discoveries expand our understanding of translational and morphological plasticity and may have significant implications for biotechnology and systems biology.