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Low-energy microalgal cell rupture by augmented osmotic swelling: single-cell analysis using microfluidic trap arrays

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ABSTRACT

Osmotic shock has been assessed for its effectiveness in cell disruption; however, existing studies have been limited to a simple increase or decrease in osmotic stress, leading to limited success. Here we test an approach of sequential increases and decrease in salinity, to intensify the mechanical stresses and better facilitate cell rupture. In this study, hyper and hypo osmotic stressors were applied individually, as well as in succession, and the effects on the physiology of populations of individual cells observed experimentally. For this, arrays of individual cells of the marine species *Tetraselmis suecica* were captured within a microfluidic trapping array and observed over a 15-hour period under varying osmotic stress conditions. Importantly, the microfluidic system enabled almost instantaneous stress application/change homogeneously across a population of individual cells (n~100). Microscopy was used in combination with fluorescent staining to track dynamic changes in cell size, the development of reactive oxygen species, cell membrane failure and death within the cell population. It was observed that standalone hypo osmotic stress (0.5M→0M NaCl) caused immediate cell expansion with the associated physical stresses on the cell wall leading to mechanical failure and death in ~90% of the cells within 9-12 hours. While hyper osmotic stress (0.5M→1M or 2M NaCl) lead to cell shrinkage, the cells remained viable. Augmented/sequential osmotic stress of (0.5M→1M→0M NaCl and 0.5M→2M→0M NaCl) resulted in more rapid and extensive cell death, with total population death and release of internal cellular components in less than 3 hours. Structural failure of the cell under augmented osmotic swelling was primarily a mechanical force. A hyper osmotic stress stage of 1 M followed by 0 M NaCl was sufficient for enhanced cell disruption. The findings have practical applications, where osmotic shock cycling can potentially be utilized as a low-cost treatment in large-scale processing of marine microalgae species. The efficient usage of water through recycling would further enhance overall sustainability.

KEY WORDS

Osmotic stress, Cell rupture, Single cell, Microfluidics

BIOGRAPHY

Sajani Piyatilleke is a PhD candidate at the University of Melbourne. Her interests are in algal processing, food, and sustainability. Her current research focuses on cell rupture of marine microalgae and the synthesis of metabolites in freshwater microalage utilizing the effects of salinity as a low-cost, low energy abiotic stressor.

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