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Effect of elevated temperature on the physiological responses of marine *Chlorella* strains from different latitudes

Bahram Barati[1,2] · **Phaik-Eem Lim**[1] · **Sook-Yee Gan**[3] · **Sze-Wan Poong**[1] · **Siew-Moi Phang**[1,4] · **John Beardall**[5]

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Abstract The increased frequency of heat waves due to climate change poses a threat to all organisms. Microalgae are the basis of aquatic food webs, and high temperatures have significant impacts on their adaptation and survival rates. Algae respond to environmental changes by modulating their photosynthetic rates and biochemical composition. This study aims to examine the effect of elevated temperature on similar taxa of marine *Chlorella* originating from different latitudes. Strains from the Antarctic, temperate zone, and the tropics were grown at various temperatures, ranging from 4 to 38, 18 to 38, and 28 to 40 °C, respectively. A pulse-amplitude modulated (PAM) fluorometer was used to assess their photosynthetic responses. Parameters including maximum quantum efficiency (F_v/F_m), relative electron transport rate (rETR), and light harvesting efficiency (α) were determined from the rapid light curves (RLCs). In addition, the composition of fatty acids was compared to evaluate changes induced by the temperature treatments. Increasing the temperature from 35 to 38 °C for both Antarctic and temperate strains and from 38 to 40 °C for the tropical strain resulted in severe inhibition of photosynthesis and suppressed growth. Although all the strains demonstrated the ability to recover from different stress levels, the tropical strain was able to recover most rapidly while the Antarctic strain had the slowest recovery. The results underline that the thermal threshold for the analysed *Chlorella* strains temperature ranges between 38 and 40 °C. Furthermore, the analysed strains exhibited different trends in their response to elevated temperatures and recovery capabilities.

Keywords Global warming · Heat stress · Photosynthesis · F_v/F_m

Introduction

Global climate change is recognised as one of the most serious environmental concerns facing the planet. According to the Intergovernmental Panel on Climate Change (IPCC), a global warming trend of 0.85 °C was recorded from 1880 to 2012 with a mean rise of 4–5 °C expected by the end of the century (IPCC, 2013). In addition to increasing mean annual temperatures, the duration, frequency, and severity of periods with exceptionally high temperatures are also rising (Easterling et al., 2000; Tripathi et al., 2016). It has been shown that climate changes are affecting the base of the food web and that these effects are transmitted up through the food chain (Montes-Hugo et al., 2009). On a global scale, species respond to thermal stress with phenological changes and distributional range shifts that often involve local extinction (Jueterbock et al., 2014). Algae are ubiquitous organisms contributing approximately 50% of the total primary production at the base of food chains worldwide (Behrenfeld et al., 2001; Beardall and Raven, 2004; Chapman 2013; Falkowski and Raven 2013).

✉ Phaik-Eem Lim
phaikeem@um.edu.my

[1] Institute of Ocean and Earth Sciences, University of Malaya, 50603 Kuala Lumpur, Malaysia

[2] Institute of Graduate Studies, University of Malaya, 50603 Kuala Lumpur, Malaysia

[3] School of Pharmacy, International Medical University, 57000 Kuala Lumpur, Malaysia

[4] Institute of Biological Sciences, University of Malaya, 50603 Kuala Lumpur, Malaysia

[5] School of Biological Sciences, Monash University, Clayton, Victoria 3800, Australia