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ORIGINAL PAPER

Differential gene expression of an Antarctic *Chlorella* in response to temperature stress

Geeng-Loo Chong · Wan-Loy Chu · Rofina Yasmin Othman · Siew-Moi Phang

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Abstract Changes in gene expression are an important response of Antarctic algae to temperature stress. The objective of this study was to investigate the differential gene expression of the Antarctic alga *Chlorella* UMACC 234 in response to temperature stress. The RNA was extracted from the cells grown at 4, 20, and 30°C and converted to cDNA by reverse transcription. Differentially expressed genes (DEG) were isolated and identified using the GeneFishing^{TM} DEG Kit (Seegene) with 20 arbitrary annealing control primers (ACP). The bands of interest were excised and purified from the agarose gel and then cloned and sequenced. A total of 22 DEG clones were isolated and identified, with 11 DEG detected only at 30°C and six DEG detected only at 4°C. Three DEG were detected at 4 and 20°C while two were detected at 20 and 30°C. The DEG were associated with functions such as photosynthesis, carbohydrate metabolism, electron transfer, and cell maintenance. Three DEG that showed high degree of similarity with sequences from the database were those code for Photosystem II P680 chlorophyll a apoprotein CP47 (PSII-CP47), aldose 1-epimerase, and a putative oxidoreductase. Real-time PCR analysis showed that the expression of the PSII-CP47 gene increased by threefold at 4°C while that of the aldose 1-epimerase and oxidoreductase genes increased by threefold and eightfold, respectively, at 30°C compared with 20°C (optimal growth temperature).

Keywords *Chlorella* · Antarctic algae · Differential gene expression · GeneFishing · Temperature stress

G.-L. Chong · R. Y. Othman · S.-M. Phang (✉)
Institute of Biological Sciences, Faculty of Science,
University of Malaya, 50603 Kuala Lumpur, Malaysia
e-mail: phang@um.edu.my

W.-L. Chu
International Medical University,
No. 126, Jalan 19/155B, Bukit Jalil, 57000 Kuala Lumpur,
Malaysia

S.-M. Phang
Institute of Ocean and Earth Sciences (IOES),
University of Malaya, 50603 Kuala Lumpur, Malaysia

Introduction

Algae are an important biotic component of the Antarctic ecosystems, as they form the basis of the food chains. Most Antarctic algae are known to grow over a broad range of temperatures. For instance, an extensive study on 35 taxa of algae from Victoria Land showed that all the isolates could grow at temperatures ranging from 7.5 to 18°C (Seaburg et al. 1981). The Antarctic *Chlorella* is known to be a eurythermal alga and can even grow over a wider range of temperatures. For instance, Hu et al. (2008) reported that two isolates of Antarctic *Chlorell*a are able to grow at temperatures ranging from 4 to 30°C. This is in contrast to polar diatoms, which are highly stenothermal, with an upper lethal temperature limit at approximately 10°C (Fiala and Oriol 1990).

The response and adaptation of Antarctic algae to temperature stress involve changes in physiological processes and biochemical composition. For instance, sea ice algae adapt to the extreme condition by producing polyunsaturated fatty acids (PUFA) and cryoprotectants, and by having high light-harvesting capacity (Morgan-Kiss et al. 2006). The antifreeze tolerance of an Antarctic strain of *Chlorella vulgaris* correlates with the increase in C18:3-fatty acid content (Hu et al. 2008). The content of 20:5