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Elevated CO_2 improves both lipid accumulation and growth rate in the glucose-6-phosphate dehydrogenase engineered *Phaeodactylum tricornutum*

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Abstract

Background: Numerous studies have shown that stress induction and genetic engineering can effectively increase lipid accumulation, but lead to a decrease of growth in the majority of microalgae. We previously found that elevated CO_2 concentration increased lipid productivity as well as growth in *Phaeodactylum tricornutum*, along with an enhancement of the oxidative pentose phosphate pathway (OPPP) activity. The purpose of this work directed toward the verification of the critical role of glucose-6-phosphate dehydrogenase (G6PDH), the rate-limiting enzyme in the OPPP, in lipid accumulation in *P. tricornutum* and its simultaneous rapid growth rate under high-CO_2 (0.15%) cultivation.

Results: In this study, G6PDH was identified as a target for algal strain improvement, wherein G6PDH gene was successfully overexpressed and antisense knockdown in *P. tricornutum*, and systematic comparisons of the photosynthesis performance, algal growth, lipid content, fatty acid profiles, NADPH production, G6PDH activity and transcriptional abundance were performed. The results showed that, due to the enhanced G6PDH activity, transcriptional abundance and NAPDH production, overexpression of G6PDH accompanied by high-CO_2 cultivation resulted in a much higher of both lipid content and growth in *P. tricornutum*, while knockdown of G6PDH greatly decreased algal growth as well as lipid accumulation. In addition, the total proportions of saturated and unsaturated fatty acid, especially the polyunsaturated fatty acid eicosapentaenoic acid (EPA; C20:5, n-3), were highly increased in high-CO_2 cultivated G6PDH overexpressed strains.

Conclusions: The successful of overexpression and antisense knockdown of G6PDH well demonstrated the positive influence of G6PDH on algal growth and lipid accumulation in *P. tricornutum*. The improvement of algal growth, lipid content as well as polyunsaturated fatty acids in high-CO_2 cultivated G6PDH overexpressed *P. tricornutum* suggested this G6PDH overexpression-high CO_2 cultivation pattern provides an efficient and economical route for algal strain improvement to develop algal-based biodiesel production.

Keywords: Glucose-6-phosphate dehydrogenase, Overexpression, Antisense knockdown, CO_2, *Phaeodactylum tricornutum*, Lipid accumulation, Algal growth rate

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