Algal Bioproducts – Investigating the Effect of Light Quality on Metabolite Production by Photosynthetic Diatoms

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Certificate of Original Authorship

I, Kenji Iwasaki declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Climate Change Cluster, Faculty of Science at the University of Technology Sydney. This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. I certify that this document has not been submitted for qualifications at any other academic institution.

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Signature: Production Note: Signature removed prior to publication.

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Preface

This thesis has been prepared in publication format, whereby each chapter represents a manuscript ready for submission to a peer-reviewed journal. Therefore, there will be some duplication in Introduction and Materials and Methods. At present, no individual chapter has been submitted for publication in a peer-reviewed journal.

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Abstract of Thesis

In Australia, between 2016 and 2017, aquaculture products made up 44% of Australian seafood product in value, reaching over $1.35 billion in production value. One of the top five profitable Australian aquaculture products during this period were edible oysters which is worth more than $112 million in production value.

Oysters are fed with live microalgae (including diatoms) during the larval, juvenile and adult stages of growth, as are other shellfish, some crustaceans, shrimps/prawns and fish. The rearing of oysters and other aquaculture products rely on the constant production of live diatoms as feed. Diatom production in Australian hatcheries are commonly recognised as the major bottleneck in oyster production, estimated to be on average, 30-40% of hatchery operational cost. In order to meet the increasing production demand diatom production must be improved, while making it economically feasible and environmentally sustainable.

In this thesis, *Chaetoceros muelleri*, a common feed for oysters, was studied for their responses to a variety of environmental growth conditions including light. To achieve this, laboratory scale photobioreactors were used to continuously monitor environmental factors to record biological responses of *C. muelleri* to different environmental conditions including light wavelengths. A brief introduction to diatom physiology and its application to aquaculture will be provided in Chapter one. The

second chapter assessed the two key environmental limitations in diatom cultivation in aquaculture facilities, light and CO_2. An empirical process model was developed to analyse the importance of light configuration to maximise light availability. High CO_2 availability coupled with high light availability significantly increased growth rates and maximum cell density. The third chapter then assessed the growth, metabolic content and cost efficiency of different colour LEDs (blue, green, red and white) based on the findings in Chapter 2. Blue light was found to be the most cost efficient in biomass and metabolite production, requiring less than half the Watt hours of other LEDs. In the fourth chapter, the wavelength of the growth light was shifted to assess its feasibility to modify metabolic content, as well as its effects on growth, photosynthesis and digestibility. The final chapter discussed the key findings of the thesis and the future research prospects. Several important avenues were identified to improve diatom production in aquaculture, such as improving light availability to increase the efficiency of CO_2 usage, blue LEDs to improve cost efficiency of biomass production and the utilization of wavelength shifting to manipulate diatom metabolite content.