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Effect of different light spectra on the growth, productivity and composition of microalgae *

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Microalgae are among the most promising renewable sources for the production of high value products, chemicals, and biofuels. The algae are unique within the Plant Kingdom in the diversity of their light-harvesting pigments in each phylum and in many of their classes. Microalgae are considered for converting light energy to chemical energy through photosynthesis. Light (both quality and quantity) is the main limits to the growth, productivity, composition and distribution of microalgae. However, photosynthesis only uses the parts of the solar spectrum in the range 400–700 nm, which is called photosynthetically active radiation (PAR).

The PAR spectrum is absorbed by various pigments with different efficiency depending on their absorption spectra. In fact the quality and intensity of the light can change simultaneously and the microalgae must adapt to both. The rate of microalgal photosynthesis depends on the rate of captured quanta, which is determined by light absorption properties of microalga cells, and intensity and spectral quality of the light field. Moreover, the efficiency of algal photosynthesis depends on the spectral overlap between solar irradiation and the pigments' absorption spectra. The achievable light to product conversion efficiency and photosynthetic productivity are the most important factor in determining cost in most microalgal production systems. Recent development in the improvement of solar energy conversion to chemical and electrical energy in microalgal production system has been proposed and developed, e.g. the solar spectral converter technology, and the combination of photovoltaic modules with microalgal culture system. In addition, the strain selection and characterisation become an important part in any developments of applied phycology.

Therefore, studies and information regarding the light quality as the main limiting factor of microalgae growth and productivity can promote the improvement of indoor and outdoor semicontinuous culture systems. Illumination of certain parts of PAR spectrum can create an optimum light utilisation for selected potential microalgae. In this research, the effect of three different light spectra—white, blue (407–488 nm) and red (621–700 nm)—on the growth, productivity and biochemical composition (lipid, protein, carbohydrate and chlorophyll content) of four potential microalgae—*Nannochloropsis* sp. strain MUR 266, *Pleurochrysis carterae* strain CCMP 647, *Cymbella* sp. strain MUR 258, *Botryococcus braunii* strain CCAP 807/2 (race B)—with different pigment profile grown in batch and semicontinuous modes were investigated. It is important to note that the amount of energy for each light spectrum was the same (2.23±0.10 W.m^{-2}), and the algae have been grown and adapted to certain light conditions for at least 20 days.

The microalgae *Nannochloropsis* sp. MUR 266 (Eustigmatophyceae; Chlorophyll *a*), *Pleurochrysis carterae* CCMP 647 (Prymnesiophyceae; Chlorophyll *a* & *c*), *Cymbella* sp. MUR 258 (Bacillariophyceae; Chlorophyll *a* & *c*) and *Botryococcus braunii* CCAP 807/2 (Trebouxiophyceae; Chlorophyll *a* & *b*) were cultured in aerated 500 mL Erlenmeyer flasks. The culture of *Nannochloropsis* sp. was grown in f/2 medium at 3.3% NaCl salinity, *P. carterae* in modified f/2 medium at 3.3% salinity, *Cymbella* sp. in f medium at 10% salinity and *B. braunii* in freshwater CHU-13 medium with a light:dark photoperiod of 12 h:12 h at 27±3°C. The initial cell density was 5 x 10^4 cells.mL^{-1}. Illumination was from the bottom of the culture system and the specific light spectrum was achieved by filters so that the cultures received an equal irradiance of 2.23±0.10 W.m^{-2} at the specific photosynthetically active radiation (PAR) wavelength and full-width half-maximum (FWHM) of unfiltered white (400–700 nm), blue (FWHM 407–488 nm) and red (FWHM 621–700 nm). The specific growth rates (μ), biochemical and chlorophyll composition, and productivities were determined using the Algae R&D Centre, Murdoch University standard methods. The repeated measures one-way analysis of variance (ANOVA) was performed using SPSS for Windows (ver. 21.0, IBM SPSS).

In summary, cells grown semicontinuously under blue light presented the highest growth rate (μ) for *Nannochloropsis* sp. (0.21) and *Cymbela* sp. (0.14), whereas for *P. carterae* the highest was obtained under white light (0.18). and for *B. braunii* under red (0.07). All species also responded differently to the light spectra with respect to their biomass, proximate composition (as a percentage of ash-free dry weight), and chlorophyll composition and productivity (g.L^{-1}.d^{-1}). Blue light enhances algal growth and metabolism of lipid and protein synthesis relatively to white or red, while the exposure of red light in contrast results an increase of carbohydrate content. A chromatic spectrum of blue and red light can be used to enhance the growth, biochemical production, and chlorophyll composition, due to the characteristics of the photosynthetic process. The exposure of a monochromatic light with a specific wavelength (blue and red) can lead to the accumulation and manipulation of microalgae growth, biomass and biochemical productivity both for enhancement and inhibition. The responses of microalgae are different and can be species-dependent based on their pigment profiles, absorption spectra and chromatic adaptive mechanisms.

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