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Effect of light quality supplied by light emitting diodes (LEDs) on growth and biochemical profiles of *Nannochloropsis oculata* and *Tetraselmis chuii*

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ABSTRACT

Biochemical components obtained by microalgal biomass can be induced by specific wavelengths and processed to high value food/feed supplements or pharma- and nutraceuticals. Two biotechnologically relevant microalgae, *Nannochloropsis oculata* and *Tetraselmis chuii*, were exposed to non-tailored LEDs light sources emitting either mono- or multichromatic light with low red but significant blue (<450 nm) photon content, or tailored light sources with high blue or high red photon emissions: fluorescent light (FL), di- or multichromatic LED mixes. Growth of *N. oculata* and *T. chuii* under tailored light resulted in a ≈ 24% increase of the average biomass productivity as compared to cultures lit by non-tailored light sources. FL induced the highest C:N ratios in both algae (*N. oculata*: 7.91 ± 0.09 and *T. chuii*: 11.29 ± 0.03), highest total lipid (48.37 ± 1.07%) in *N. oculata* and carbohydrate (55.31 ± 1.02%) in *T. chuii* biomass. Among non-tailored light sources, monochromatic LEDs with emission peaks 465, 630 and 660 nm induced a ≈ 29% increase of carbohydrates and a ≈ 20% decrease of protein levels as compared to LEDs peaking at 405 nm and cool- and warm white LEDs. In conclusion, as FL have low photon conversion efficiencies (PCE), particularly within the red wavelength range, LEDs emitting at the 390–450 and 630–690 nm wavebands should be combined for optimal carbon fixation, nitrogen and phosphate uptake.

1. Introduction

Microalgae can be biotechnologically processed into products, such as bulk food, feedstock for food/feed supplements, nutraceuticals and cosmetics and they have also been considered to be a promising feedstock for biofuel production [1,2]. Microalgal biochemical composition, and thus the levels of target added-value biomolecules, can change due to shifting environmental parameters and/or phases of the algal lifecycle [3,4].

Light quality and quantity supplied by sun- or artificial light is one of the most important parameters for phototrophic organisms, as it is required for photosynthesis and the regulation of several cellular processes [1,2,5–9]. Even though sunlight is the most cost-effective energy source to produce microalgae, artificial light may become economically feasible when production of high value biomolecules is considered [1,10]. The key advantage of using artificial light for microalgal production relies on a stricter regulation of parameters that significantly impact cell proliferation, such as the photosynthetic photon flux density (PPFD), photoperiod and light spectra. This tighter control of light availability can maintain cell growth 24 h per day even in outdoor facilities, because nightly biomass losses via respiration are prevented when dark periods are precluded [11]. In addition, the control of light quality and intensity leads to lower variability and a higher control of microalgae biomass productivity and target biochemical composition.

Artificial lighting in microalgal research and production is usually achieved by means of fluorescence lamps (FLs) [2] or, alternatively, by light-emitting diodes (LEDs) [1,12–14]. LEDs are mercury-free and fast-responding artificial light sources. As they can be dimmed and have long lifetimes (~50,000 h), LEDs can be used to cut costs both in terms of energy and equipment maintenance [12–14]. The use of FLs or LEDs, however, comes at a cost and their improvement in terms of photosynthetic and electric efficiency is essential to obtain a wider and cheaper array of products from microalgae cultivated under artificial light [1]. However, FLs are energetically inefficient, as they emit wide emission spectra, including wavelengths with low photosynthetic activity for certain phototrophs, whereas LEDs can be designed to emit only the required wavelengths.

Hence, LEDs can provide not only a more sustainable control of supplemental light during microalgal growth, but also adjust the biochemical composition of the biomass by means of single wavelengths at different light intensities and/or pulse light frequencies [15–19]. Although studies about the cultivation of microalgae under different

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light qualities supplied by LEDs have increased in recent years, there are still important gaps in the knowledge of how microalgae respond to light. The combined use of LEDs for microalgal cultivation or general metabolic response patterns was only partly investigated (reviewed by Schulze et al. [14]).

In order to fill in the gaps, found in the current state of the art, the present study aims to determine the effects of light quality on the growth rate, biochemical composition, morphological and physiological properties of *Nannochloropsis oculata* and *Tetraselmis chuii* through the application of different (blue, red, white) LED and FL light sources.

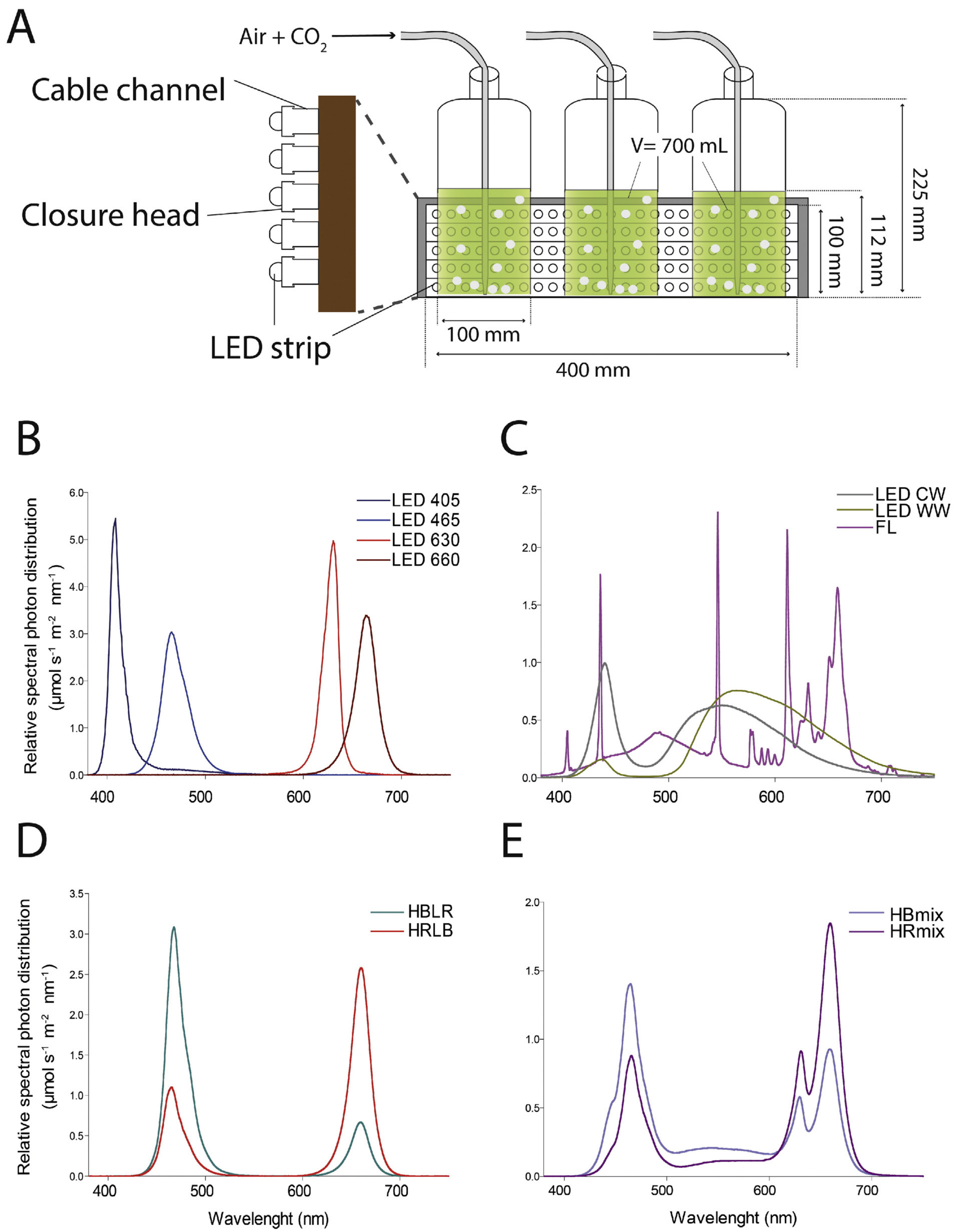

Fig. 1. Diagram of the experimental setup: (A) Photon distribution between 380 and 750 nm of the light sources under study; (B) single colour LEDs; (C) mixed spectra light sources; (D) two-colour mix adapted spectra and (E) Multi-colour mix spectra. (*2-column fitting image*). (For interpretation of the references to colour in this figure, the reader is referred to the web version of this article.)