Extended Abstract

Effect of Lighting on the Intensification of Phycocyanin Production in a Culture of *Arthrospira platensis* †

Dawid Szwarc * and Marcin Zieliński

Department of Environmental Sciences, Department of Environmental Engineering, University of Warmia and Mazury in Olsztyn, ul. Warszawska 117A, 10-720 Olsztyn, Poland; marcin.zielinski@uwm.edu.pl

* Correspondence: dawid.szwarc@uwm.edu.pl; Tel.: +48-664-159-647

† Presented at Environment, Green Technology and Engineering International Conference (EGTEIC 2018), Caceres, Spain, 18–20 June 2018.

Published: 22 October 2018

**Abstract:** The global market shows high demand for products of natural origin to reduce the use of synthetic substances in the food, pharmaceutical and cosmetics industries. One of the opportunities for acquiring natural compounds of industrial value is the use of cyanobacteria biomass. In terms of biomass composition, cyanobacteria of the species *Arthrospira platensis* deserve particular attention. They are characterised by high contents of protein, γ-linolenic acid, polysaccharides, β-carotene, chlorophyll and phycocyanin. Phycocyanin is a pigment-protein complex widely used in the food and cosmetics industry. It is also used as fluorescent probes in histochemistry, fluorescence microscopy, flow cytometry and fluorescence immunoassay. Due to the extensive use of phycocyanin in various industries, a high demand for this pigment is generated, which determines the search for methods of intensifying phycocyanin production by the cells of *A. platensis*. The aim of the study was to determine the effect of light of different wavelengths on phycocyanin productivity by cyanobacteria of the species *Arthrospira platensis*. The highest biomass concentration and phycocyanin concentration were obtained in a culture using Red LED lighting.

**Keywords:** *Arthrospira platensis*; phycocyanin; light

1. Introduction

The global market shows high demand for products of natural origin to reduce the use of synthetic substances in the food, pharmaceutical and cosmetics industries. This has led to a growing interest in biotechnological research focused on increasing the rate and efficiency of acquiring natural products through the elimination of the main limiting factors, such as e.g., crop seasonality. One of the opportunities for acquiring natural compounds of industrial value is the use of cyanobacteria biomass that exhibit high biomass productivity and can be cultured in photobioreactors, which restricts the impact of external conditions on the culture and hinders the access of both parasites and competing microorganism species [1]. In terms of biomass composition, cyanobacteria of the species *Arthrospira platensis* deserve particular attention. They are characterised by high contents of protein, γ-linolenic acid [2], polysaccharides [3], β-carotene [4], chlorophyll and phycocyanin [5]. The species *Arthrospira platensis* is cultured on a commercial scale for the extraction of phycocyanin, a compound with a high added value which is used in a variety of industries.

Phycocyanin is a pigment-protein complex used in food products to increase nutritional value. It is used as food colourants, antioxidants and emulsifiers which can replace or reduce the use of synthetic additives. The substance is also widely used as a pigment in the cosmetics industry and as a fluorescent biomarker in laboratory testing [6].
Photosynthesising organisms such as *Arthrospira platensis* can be cultivated using advanced technologies enabling thorough monitoring and controlling the conditions as well as in open ponds [7]. The provision of adequate lighting is one of the most important factors affecting the biomass productivity and the content of assimilation pigments. Scientific research has shown that the type of light source and the wavelength not only affect biomass productivity but also the chemical composition of cyanobacteria [8,9].

The aim of the study was to determine the effect of light of different wavelengths on phycocyanin productivity by cyanobacteria of the species *Arthrospira platensis*.

2. Materials and Methods

2.1. Microorganism Strain and Culture Medium

The biomass of cyanobacteria *Arthrospira platensis* used in the experiment originates from a culture carried out under controlled conditions, initiated from a culture acquired from the Experimental Phycology and Culture Collection of Algae Centre in Göttingen. In the experimental culture, a modified medium Aiba and Ogawa was used [10].

2.2. Culture Condition

*Arthrospira platensis* were cultivated in pipe photobioreactors with a vertical orientation and an active volume of 2 dm³. The temperature of the culture was 30 ± 1 °C. The test stand was equipped with an aeration pump connected to the reactors from below. This solution supplied carbon dioxide to the system and mixed the cyanobacteria culture. The volumetric aeration ratio was 0.6 v/v.

2.3. Light Sources

The study was divided into three experimental series with the light source as the division criterion:

- Red—Red LED (660 and 630 nm),
- Blue—Blue LED (470 and 430 nm),
- White—White fluorescence lamp (5600 K).

In the experimental series using LED lighting, modules comprised of 1 Watt Helixon diodes were used (Helio Opto, Zhubei, Taiwan). Each module comprised 28 diodes and a 36 W power supply unit (Philips, Amsterdam, The Netherlands). In the control series using a fluorescent lamp, a 28 W lamp with a colour temperature of 5600 K was used (Osram, Munich, Germany).

2.4. Measurement of Biomass Concentration

Dry matter content, or total solids (TS) was determined by filtering 50 mL of culture samples through a 110 mm diameter hard cellulose filter. Following the filtering process, the filter was dried in a laboratory oven (Binder, Tuttlingen, Germany) until a constant weight was obtained. In order to determine dry matter content, the difference between the weight of a dried empty filter and the weight of a dried filter following filtration was determined.

2.5. Phycocyanin Extraction

To extract phycocyanin from the *Arthrospira platensis* cells, 0.5 g dry biomass was added to 50 cm³ phosphate buffer (pH of 7.0). The prepared solution was subjected to ultrasonic disintegration. The ultrasonic treatment process was carried out using a 400 W UP400S ultrasonic processor with a frequency of 24 kHz (Hielscher, Teltow, Germany). The ultrasound amplitude was 70%, and the disintegration time was 30 s. Following the ultrasonic disintegration process, the samples were shaken in the dark for 4 h. The samples were then centrifuged at 9000×g for 15 min and the supernatant was subjected to a spectrophotometric analysis.
2.6. Determination of Phycocyanin Concentration

After centrifugation, the supernatant’s optical density was measured using a DR5000 spectrophotometer (Hach, Loveland, CO, USA). Phycocyanin content (PC, mg/cm³) was calculated according to the following equation [11]:

\[ PC = \frac{OD_{615} - 0.474 (OD_{652})}{5.34}, \]  

where \( OD_{615} \) is the optical density of the sample at 615 nm, and \( OD_{652} \) is the optical density of the sample at 652 nm.

3. Results and Discussion

Effects of Light Wavelength on Cell Growth and Phycocyanin Content

In the experiment, cyanobacteria *Arthrospira platensis* were cultured using various light sources i.e., a fluorescent lamp and red, blue, and red-blue electroluminescent diodes, and the illuminance of light emitted on the photobioreactor surface was 2500 lux. The initial biomass concentration in all experimental series was 0.369 ± 0.014 g TS/dm³. As shown in Figure 1a, the highest biomass concentration was obtained in the culture with Blue-Red LED lighting and it amounted to 5.619 ± 0.053 g TS/dm³. In terms of biomass concentration, the culture using Red LED lighting appeared to be the second highest with a value of 3.915 ± 0.083 g TS/dm³. The lowest biomass concentration of 2.789 ± 0.032 g TS/dm³ was noted in the culture lit by the fluorescent lamp. The experiment results are consistent with a study by Lee et al. [12], the *Arthrospira platensis* were cultured using two light sources: Red LED (625 nm) and Blue LED (450 nm). The obtained results show that a higher biomass concentration of 3.0 g TS/dm³ was obtained in the culture using Red LED lighting. Wang et al. [13] and Chen et al. [14] investigated the growth of *Arthrospira platensis* using red, yellow, blue, white and green LED diodes. They observed that the highest biomass concentration is obtained when using a red LED diode.

![Figure 1. Effects of light wavelength on: (a) biomass concentration, (b) phycocyanin concentration.](image)

Figure 1b shows the effect of light of different wavelengths on phycocyanin content and phycocyanin productivity of *Arthrospira platensis*. The highest phycocyanin content was noted for biomass cultured using Red LED lighting and it amounted to 17.61 ± 0.51%. The culture with Blue LED lighting was characterised by the lowest phycocyanin content in the cells, which was 2.47 ± 0.03. Lima et al. [15], when researching the effect of the spectral quality of light on the accumulation of pigments in *Arthrospira platensis* biomass, also observed that the highest phycocyanin concentration (16.71%) was obtained with the use of a red LED (660 nm). On the other hand, when a blue light (450 nm) was used, no presence of phycocyanin was demonstrated in *Arthrospira platensis* biomass. Chen et al. [14], when researching the effect of red, white, blue, yellow and green LEDs, also observed the highest phycocyanin content of 15.2% TS in the culture using red light.
4. Conclusions

This study concerning the effect of lighting on the intensification of phycocyanin production in a culture of *Arthrospira platensis* demonstrated that the light spectrum affected both an increase in the biomass of the tested cyanobacteria, phycocyanin content of the biomass.

The highest biomass concentration and phycocyanin concentration were obtained in a culture using Red LED lighting.

**Author Contributions:** D.S., M.Z. conceived and designed the experiments; D.S. performed the experiments; D.S. analyzed the data; D.S. contributed reagents/materials/analysis tools; D.S. wrote the paper

**Conflicts of Interest:** The authors declare no conflict of interest.

**References**


© 2018 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).