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Investigation of main factors affecting the growth rate of Spirulina

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ABSTRACT

Spirulina is a kind of microalgae with high economic value, therefore, investigations of the growth of Spirulina are of great importance. In this paper, the effect of culture conditions (temperature and pH), culture medium, light source (single and combined light source) and the corresponding exposure time on the growth rate of Spirulina is extensively studied. The results showed that the optimal temperature and pH for the growth of Spirulina were 30 °C and 9.5–10.0, respectively, while the culture medium with 10 g/L of $NaHCO_3$, 2 g/L of $NaNO_3$, 0.6 g/L of KH_2PO_4, 0.2 g/L of $MgSO_4{\cdot}7H_2O$ and 1.2 g/L of K_2SO_4 achieved the best growth rate of Spirulina. When being exposed to the red light (wavelength, 620–630 nm), blue light (wavelength, 465–475 nm) and green light (wavelength, 522–532 nm), the maximum dry matter contents of Spirulina were 1.346 g/L, 1.179 g/L and 1.081 g/L, respectively, indicating that the red light was the best light source for the growth of Spirulina as a highest growth rate with an dramatic increase of 56.69% (compared to the control group) in the dry matter content was observed. 8 h were proved to be the best exposure time of red light for the growth of Spirulina within one day, where a dry matter content of 1.440 g/L was found. This was 67.64% higher than that of the control group. Combined light sources of red-blue light, red-green light and blue-green light were also applied to Spirulina, and it was found that the maximum dry matter contents of Spirulina were 1.518 g/L, 1.389 g/L and 1.232 g/L for red-blue light, red-green light and blue-green light respectively. Therefore, the Spirulina exposed to red-blue light attained the highest growth rate with the corresponding dry matter content increasing by 76.72% when compared with the control group.

1. Introduction

Spirulina, a kind of microalgae with high economic value, is one of the few microalgae that are suitable for large-scale cultivation due to its high photosynthetic efficiency, fast growth rate and great adaptability to the environment. Researches have proved that Spirulina with the properties of anti-fatigue, anti-radiation and anti-viral can be used to suppress the growth of tumor and enhance the immunity, which opens up opportunities for the application of Spirulina in the area of functional foods [1–4].

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Table 1
Factors and levels of the orthogonal design.

level	A	B	C	D	E
1	28.00	3.00	0.60	0.40	1.40
2	22.00	2.50	0.40	0.30	1.20
3	16.00	2.00	0.20	0.20	1.00
4	10.00	1.50	0.10	0.10	0.80

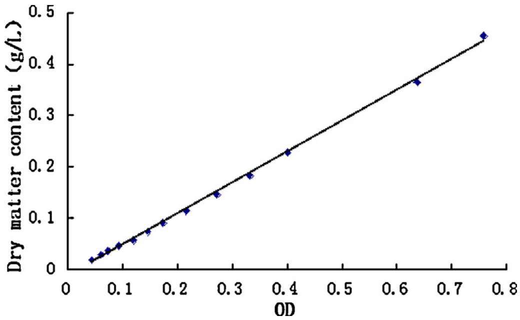

Fig. 1. The calibration curve.

The previous studies have focused on the morphology, breeding habits, nitrogen fertilizer, the storage of algae species, production conditions and classification of Spirulina [5–9], and investigations in the influence of illumination on the growth of Spirulina mainly focused on the time and intensity of illumination rather than the light wavelength and the application of combined light source. To fill this gap, the impact of the light source, including wavelength and the combined light source, on the growth rate of Spirulina with different culture conditions were studied in this paper. Further, the culture medium and the expose time of light were optimized, aiming to provide reference for the aquaculture industry of Spirulina.

2. Materials and methods

2.1. Materials

2.1.1. Algal species

The algal species was spirulina platensis, and obtained from Wuchuan Biological Breeding Base, Guangzhou City Green Biotechnology Development Co., Ltd. (Wuchuan, China).

2.1.2. Culture medium

The Zarrouk culture medium was (g/L): $NaHCO_3$, 16.80; $NaNO_3$, 2.50; NaCl, 1.00; KH_2PO_4, 0.41; K_2SO_4, 1.00; $MgSO_4 \cdot 7H_2O$, 0.20; $CaCl_2 \cdot 2H_2O$, 0.04; $FeSO_4 \cdot 7H_2O$, 0.01; Na_2EDTA, 0.08; adding the trace element solution A_5 1.0 mL and B_6 1.0 mL.

The trace element solution A_5 was (g/L): H_3BO_3, 2.86; $MnCl_2 \cdot 4H_2O$, 1.80; MoO_3, 0.01; $ZnSO_4 \cdot 7H_2O$, 0.22; $CuSO_4 \cdot 5H_2O$, 0.08.

The trace element solution B_6 was (g/L): NH_4VO_3, 22.90; $NiSO_3 \cdot 7H_2O$, 47.80; $NaWO_4$, 17.90; $Ti_2(SO_4)_3$, 40.00; $Co(NO_3)_2 \cdot 6H_2O$, 4.40.

2.2. Methods

2.2.1. Preparation of algae stock solution

Algae species and the medium were placed into a glass cylinder (100 cm × 50 cm × 50 cm) with a volume ratio of 1:20. Then this algae solution was cultured by two fluorescent lights (30 W) with the light cycle of L: D = 12 h: 12 h. The algae solution was cultured under stirring by a turbine stirrer (12 W) with a period of 10 min/h until a largest concentration was obtained.

2.2.2. Calibration curve of Spirulina

1000 mL cultured algae solution was filtered with the filter paper. The filtered algae mud was washed with distilled water several times to remove the salt absorbed on the frond surface. This cleaned algae mud was dried in the vacuum oven at 80 °C until a constant weight was obtained, which was used to calculate the dry matter content of Spirulina (c). Algae solutions with various dry matter content of Spirulina were prepared and their optical density (OD) values at 560 nm were measured. The calibration curve was obtained by plotting OD to the dry matter content: $c = 0.6034OD - 0.0129$ ($R^2 = 0.9985$). It is shown in Fig. 1.