Production and nutritive value of *Spirulina platensis* in reduced cost media

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**KEYWORDS**

*Spirulina platensis*; Mass production; Reduced Cost medium; Cyanobacteria; Nitrogen source

**Abstract** This study aimed to provide a cost effective medium to large scale production of *Spirulina platensis*. This intention was implemented by substituting all the nutrients present in Zarrouk’s medium (SM) with cheaper and locally available commercial fertilizers and chemicals. The Reduced Cost medium contained single super phosphate (SSP), commercial sodium bicarbonate, Muriate of potash (MOP) and crude sea-salt, (Syahat salt). Four grades of nitrogen concentrations representing 10%, 20%, 30% and 40% of SM nitrogen concentration (29.42 mM-N) were taken from ammonium nitrate (Treatments 1–4) or urea (Treatments 5–8) respectively, for testing. The alga was grown for 33 days at 30 ± 2 °C, pH 9, 30 µEm⁻² s⁻¹ irradiance. The growth characteristics (maximum biomass Xₘ, cell productivity Pₓ, specific growth rate µₘ and chlorophyll concentration), and biochemical composition (proteins, carbohydrates and lipids) of the alga grown in these media were compared with that cultivated in SM. Significant differences in the growth parameters and biochemical composition were observed for the different nitrogen sources and concentrations. The results revealed that *S. platensis* could utilize ammonium nitrate most efficiently and that growth was enhanced with increasing the concentrations of ammonium nitrate giving maximum biomass at 0.353 g/L (Treatment 3). Further increasing the concentration limited growth. The growth parameters in urea showed a significant decrease associated with increasing urea concentrations. The maximum biomass, chlorophyll and protein yield (0.813 ± 0.018 mg/L, 0.0685 ± 0.0024 µg/L and 52.62%, respectively) were recorded using Treatment 3 which was comparable with that of SM (0.840 ± 0.008 mg/L, 0.0701 ± 0.0089 µg/L and 52.95%, respectively). The results indicated that

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the newly prepared medium can be used profitably for large-scale mass production of protein-rich *Spirulina* and yields similar performance with cost effective to Zarrouk’s medium. © 2012 National Institute of Oceanography and Fisheries. Production and hosting by Elsevier B.V. All rights reserved.

**Introduction**

*Spirulina* is a multicellular, filamentous cyanobacterium which can colonize environments that are unsuitable for many other organisms, forming populations in freshwater and brackish lakes and some marine environments, mainly alkaline saline lakes (Vonshak, 1997). *Spirulina* contains a high content of protein (up to 70%), along with high amounts of essential fatty acids, essential amino acids, minerals, vitamins (especially B₁₂), antioxidant pigments (phycobiliproteins and carotenoids) and polysaccharides (Belay et al., 1993; Vonshak, 1997). Consequently, the commercial production of *Spirulina* has gained worldwide attention for use in human food supplements, animal feed and pharmaceuticals. In aquaculture, *Spirulina* is used as a feed additive to improve growth, feed efficiency, carcass quality, and physiological response to disease in several species of fish (Mustafà et al., 1994). Furthermore, it is the richest algal source of Gamma-linolenic acid (GLA), a precursor for the biologically-active compound (prostaglandins, PGE₁) (Habib et al., 2008) which is necessary for the enhancement of the immune system in shrimp larvae (Belay et al., 1993; Vonshak, 1996; Yuan-Kun et al., 2003). In addition to its good nutritional value, the evidence for its potential therapeutic application is overwhelming (Belay et al., 1993; Belay, 2002).

The growth of *Spirulina* and the composition of the biomass produced depend on many factors, the most important of which are nutrient availability, temperature and light (Cornet et al., 1992). In addition, *Spirulina* requires relatively high pH values between 9.5 and 9.8 (Belkin and Boussiba, 1971), which effectively inhibits contamination by most algae in the culture. Production of *Spirulina* with reduced costs is necessary when considering large-scale cultivation for industrial purposes. The cost of nutrients is considered the second major factor influencing the cost of *Spirulina* biomass production after labor (Vonshak, 1997). Zarrouk’s medium has successfully served as the standard medium (SM) for *Spirulina* culture for many years (Zarrouk, 1966). Consequently, many media have been developed using seawater (Faucher et al., 1979), sewage water (Saxena et al., 1982) and industrial effluents (Tanticharoen et al., 1993).

Therefore, the present study was undertaken to evaluate the growth of *Spirulina platensis* in a medium based on commercial grade chemicals and fertilizers and to compare the growth characteristics and biochemical composition of the produced organism with that cultivated in Zarrouk’s medium. This will allow the derivation of a new medium to assist in decreasing the cost of *Spirulina* production.

**Materials and methods**

**Microorganism**

The cyanobacterium *S. platensis*, strain K-2, used in the present study was obtained from the Freshwater Hydrobiology Laboratory, National Institute of Oceanography and Fisheries (NIOF), Cairo, Egypt. The strain was maintained in 500 mL sterilized Erlenmeyer flasks containing 100 mL Zarrouk’s medium (Zarrouk, 1966) at 30 ± 2 °C, pH 9 with continuous illumination using cool white fluorescent tubes (2500 Lux) and twice daily shaking by hand.

**Culture media and experimental design**

All constituents of Zarrouk’s medium were autoclaved without bicarbonate salt, which was sterilized by filtration, and used as the standard control medium (SM). To prepare the new Reduced Cost media, all of the constituents present in Zarrouk’s medium were substituted with commercial fertilizers and other cost-effective ingredients. Sodium nitrate was substituted with one of two nitrogen sources: ammonium nitrate (NH₄NO₃) or urea [CO(NH₂)₂]. Four grades of nitrogen concentrations representing 10%, 20%, 30% and 40% of SM nitrogen concentration (29.42 mM-N) were taken from ammonium nitrate (Treatments 1–4) or urea (Treatments 5–8), respectively for testing. Analytical grade potassium hydrogen phosphate (K₂HPO₄) was substituted with single super phosphate fertilizer SSP [Ca(H₂PO₄)₂·H₂O], to provide a source of phosphorus. Analytical grades of sodium bicarbonate (NaHCO₃), potassium sulfate (K₂SO₄) and sodium chloride (NaCl) were substituted with commercial grades of NaHCO₃, Muriat of potash (MOP) and crude sea-salt (Syahat salt, NaCl raw material), respectively, with concentrations equivalent to that found in SM. The composition of SM and the Reduced Cost media are shown in Table 1.

Sterilized Erlenmeyer flasks (500 mL) containing 100 mL of either SM or the Reduced Cost media, were used as culture units. Cultures were initially inoculated with *S. platensis* biomass concentration of 0.06 mg/L dry weight. The experiment was carried out in triplicates for 33 days at 30 ± 2 °C, pH 9, under 30 μEm² s⁻¹ irradiance using cool white fluorescent lamps with a photoperiod cycle of 12:12 h light/dark and thrice daily shaking by hand.

**Multiplication characteristics evaluation**

Biomass concentration was determined every three days by measuring the optical density at λ 560 nm to produce a standard curve (Leduy and Therien, 1977). This standard curve was subsequently used to calculate the biomass of individual samples based on their optical density. The dry weight of biomass was determined by filtration of sample (10 mL) through dried preweighed Gelman GA-6 filter (Ø 47 mm and nominal pore size 0.45 μm). The biomass obtained was washed twice with distilled water, dried at 80 °C for 4 h, cooled in desiccator and the resulting dry weight determined (Olguin et al., 2001). Chlorophyll content was determined by filtering 5 mL of cultivation medium in late exponential phase through GF/C filters (Ø 47 mm and nominal pore size 0.45 μm). The material was submitted to extraction with acetone and chlorophyll a was measured spectrophotometrically according to American Public Health
was evaluated using the following equations:

\[ P_e (\text{mg/L/day}) = (X_m - X_0)/t_m \]

where: \( X_0 \) = initial cell concentration (mg/L), \( X_m \) = maximum cell concentration (mg/L), \( t_m \) = cultivation time related to maximum cell concentration (days).

(2) Maximum specific growth rate \( (\mu_m) \) and doubling time \( (t_d) \) according to Levasseur et al. (1993),

\[ \mu_m (\text{div/day}) = \ln (X_2/X_1)/t_2 - t_1 \]

\[ t_d (\text{day}) = \ln 2/\mu = 0.693/\mu, \]

where: \( X_1 \) = cell concentration at time \( t_1 \), \( X_2 \) = cell concentration at the time \( t_2 \).

Biochemical analysis

Aliquots from culture units in late exponential phase were filtered through GF/C filters (pore size 0.45 μm) and kept frozen at –80 °C for biochemical composition analysis. For protein analysis, filters were homogenized with 5 mL of 10% trichloroacetic acid to precipitate protein (Dorch et al., 1984), and the protein concentration was determined using the method described by Lowry et al. (1951) and modified by Clayton (1988) after re-dissolving precipitated protein in NaOH (1 M). Total cellular carbohydrate was determined according to Dubious et al. (1956) and total lipids were estimated using sulfophosphovanilin method as described by Chobral and Castelleno (1961).

Statistical analysis

Data were statistically analyzed by one-way analysis of variance (ANOVA) using SPSS version 17 (SPSS Inc., Chicago, IL, USA). Duncan’s multiple range test was used to compare differences between treatment means when significant F values were observed, at \( p \leq 0.05 \) level (Duncan, 1955).

Results

The growth rates of \( S. \) platensis, expressed as dry weight (mg/L), in SM and the Reduced Cost media are shown in Fig. 1a and b. The growth curves lacked a lag phase for both SM and the Reduced Cost media. A rapid increase in biomass values was observed in SM giving the maximum biomass values (0.840 ± 0.008 mg/L on the 15th day). In contrast, a gradual increase in the dry weight was seen at all concentrations of the Reduced Cost media but with different rates of increase. The growth curves for different concentrations of the Reduced Cost media showed similar growth rate behavior with peak biomass concentrations being observed between the 27th and 33rd days. In each case the peak biomass value differed.

In cultures supplemented with ammonium nitrate, the increase in the concentration of ammonium nitrate was associated with increased growth rate in treatments up to number 3, the growth rate was greatly reduced with the addition of a higher concentration of ammonium nitrate (Treatment 4). The maximum biomass obtained at different ammonium nitrate concentrations was 0.591 ± 0.018 and 0.813 ± 0.018 mg/L for Treatments 4 and 3, respectively, with a longer increase in the concentration of ammonium nitrate was associated with increased growth rates up to number 8. The maximum biomass obtained at different ammonium nitrate concentrations was 0.360 ± 0.003 and 0.640 ± 0.006 mg/L for Treatments 8 and 5, respectively (Fig. 1b).

Table 2 shows the maximum chlorophyll \( a \) concentration (chl \( a_m \)), cell productivity \( (P_e) \), maximum specific growth rate.
In all variants of the new medium, highest values of cell productivity (\( \mu_m \)) increased with increasing urea concentration. Values of chl \( a_m \), \( \mu_a \) and \( \mu_m \) coupled with an increased doubling time compared with that observed in SM. The growth parameters showed the same trends seen with changes in dry weight: values of chl \( a_m \), \( P_s \) and \( \mu_m \) showed a direct increase with increasing concentration of ammonium nitrate up to Treatment 3 then decreased for Treatment 4; while parameters decreased with increasing urea concentration. Values of chl \( a_m \) for SM and Treatment 3 (0.0701 ± 0.0089 and 0.0685 ± 0.0024 \( \mu g/L \), respectively) were close although their \( P_s \) (0.052 ± 0.0005 and 0.028 ± 0.0006 \( mg/L/day \), respectively) and \( \mu_m \) (0.321 ± 0.010 and 0.233 ± 0.016 \( div/day \), respectively) significantly different (\( p < 0.05 \)). Although the highest values of cell productivity (\( P_s \)) were recorded on different days of incubation for SM and different concentrations of the Reduced Cost media, the maximum specific growth rate (\( \mu_m \)) for all culture was observed between the 3rd and 6th days.

The percentages of protein (52.95 ± 0.53), carbohydrate (13.20 ± 0.57) and lipid (7.16 ± 0.68) contents obtained with SM were comparable with that observed for Treatment 3 (Table 3). Compared to SM, protein content of \( S. \ platensis \) cultivated in all concentrations of urea and Treatment 4 was significantly decreased (ranging between 37.79 ± 7.64 and 47.10 ± 6.67), while carbohydrate content was increased (ranging between 16.01 ± 4.24 and 24.50 ± 2.49). Lipid content showed different pattern with insignificant lower values in ammonium nitrate and significant higher values (\( p < 0.05 \)) in urea (ranging between 5.64 ± 0.11 and 15.39 ± 1.32).

**Discussion**

In mass cultures of microalgae, nutrition condition is one of the key factors that controls their growth and productivity (Vomshak and Richmond, 1988; Faintuch et al., 1991). This investigation was conducted with the basic aim of providing a simple and inexpensive medium to decrease the cost of large scale production of \( S. \ platensis \). This intention was implemented by substituting all the nutrients of Zarrouk’s medium with cheaper and locally available commercial fertilizers and chemicals.

Among the nutrients required for the growth of algae, phosphorus is considered as an important element which plays an essential role in maintaining high production rates of microalgae (Mostert and Grobbelaar, 1987). Commercial agriculture fertilizer, SSP, was selected as a source of phosphorus (16% \( P_2O_5 \)), and as a supplier of (EDTA) and some essential micronutrients, since it contains these elements as impurities. Raoof et al. (2006) have grown successfully \( S. \ platensis \) in Zarrouk’s medium substituted with SSP in place of \( K_2HPO_4 \), EDTA and \( A_3 \) micronutrient solution. Becker (1994), reported that the best required phosphate concentration for growth of microorganisms falls in a wide range (between 0.05 and 20 mg/L), and does not depend on the concentration of other nutrients. However, the concentration of phosphate in the present study was adjusted to be the same as SM, which is above Becker’s concentrations. In addition, SSP contains reasonable amount of calcium (19–25%) and sulphur (8–12%) which meets the requirement for these nutrients.

Other expensive chemical, such as \( K_2SO_4 \), were substituted with using commercial grade fertilizer, MOP. The concentration of MOP was adjusted to supply amount of potassium equivalent to that provided by \( K_2SO_4 \) in SM. The advantage of utilizing crude sea-salt (Syahat salt) was that the macro and micro-nutrients required for \( S. \ platensis \) growth are mainly provided by this kind of low-cost raw material.

Changes in nitrogen source and amount of cultivated media limit the intensive growth of microalgae and alter their pigment and biochemical composition (Mostert and Grobbelaar, 1987). Cyanobacteria preferentially use inorganic nitrogen for growth, particularly nitrates and ammonium but some of them are able to grow on organic nitrogen (Fogg et al., 1973). In the present study, different concentrations of two nitrogen sources were tested to determine their effectiveness on productivity of \( S. \ platensis \). Ammonium nitrate and urea were chosen because they are cheaper than others (e.g. potassium nitrate, sodium nitrate or ammonium chloride), and contain two nitrogen atoms (35% and 46% nitrogen, respectively) whereas other nitrates have only one (14–16% nitrogen).

When the response of \( S. \ platensis \) grown in SM and the Reduced Cost media was monitored, the results showed significant differences in the growth parameters for the different nitrogen sources. There was no lag phase in the growth curves of SM and the new media because initial inocula were \( S. \ platensis \) cells that had been harvested in exponential phase, thus the alga grew immediately, independent of different nitrogen source. The final biomass yield in ammonium nitrate was comparable with that seen using SM but with a longer exponential phase and greater doubling time (\( t_d \)). Growth in urea was poor giving significantly lower biomass (\( p < 0.05 \)) than that of either SM or ammonium nitrate. In spite of the increased
length of the exponential phase and the increased $t_d$ in ammonium nitrate and urea when compared with SM may be due to adaptation to the different media by *S. platensis*.

The results revealed that *S. platensis* could most efficiently utilize ammonium nitrate as compared to urea. The high values of specific growth ($\mu_m$) for ammonium nitrate confirmed that the metabolic efficiency of the alga was best on ammonium nitrate. Although urea has been recognized as a good nitrogen source, nitrate is the more convenient because it may be provided to the culture at high concentrations while ammonium and urea are toxic at concentrations higher than 2 mM. The combination between nitrate and ammonium salts were toxic at concentrations higher than 2 mM. The preference for nitrate and ammonium salts as a nitrogen source was demonstrated by Richmond (1988) who reported that nitrates and ammonium salts were the main nitrogen sources assimilated by *Spirulina* as well as urea in lesser concentration. The higher growth rate in ammonium nitrate may be due to a greater efficiency of ammonia grown cells in the conversion of photosynthetically generated reducing power into net growth as mentioned by Rhee and Lederman (1983). Several studies have shown that nitrate and ammonium ions appear to be actively transported in cyanobacteria, while it enters into the cells of alkalophilic species such as *Spirulina* by passive diffusion (Bousbia, 1990; Rodriguez et al., 1994).

The growth of *S. platensis* was enhanced by increasing the concentration of ammonium nitrate giving the maximum biomass in Treatment 3, which was comparable with that of SM while further increasing in the ammonium nitrate concentration limited growth. On the other hand, the growth rate of *S. platensis* in urea showed a significant decrease associated the increase in urea concentration giving the best biomass production at the lowest concentration (Treatment 5). This may be due to the inhibitory effect of urea on *Spirulina* production at concentration more than 0.3 g/L as mentioned by Richmond (1990). Filali et al. (1997) concluded that among inorganic and organic nitrogen sources, nitrate is the more convenient because it may be provided to the culture at high concentrations while ammonium and urea are toxic at concentrations higher than 2 mM. The combination between nitrate and ammonium salts sustained the efficiency as nitrate if maintained at lower concentrations, giving higher growth rates and reduced toxicity. This may explain our finding that to obtain the maximum biomass of *S. platensis*, the concentration of ammonium nitrate or urea should not be more than 8.83 or 2.94 mM N, respectively.

For a long time, condition of the culture nutrition has been recognized one of the important factors that plays a major role in determining the biochemical composition of microalgae (Mostert and Grobbelaar, 1987). The present results revealed that the presence of variations in the protein, carbohydrate and lipid contents produced in respect to nitrogen source type and concentration. Although these variations in some treatments were not large, significant differences ($p < 0.05$) were observed in many treatments. Considering, ammonium nitrate, the higher concentrations gave higher values for cellular proteins and carbohydrates. Since nitrogen is required for

### Table 2 Maximum chlorophyll (Chl $a_m$), cell productivity ($P_s$), maximum specific growth rate ($\mu_m$) and doubling time ($t_d$) of *S. platensis* grown on SM and the Reduced Cost media.

<table>
<thead>
<tr>
<th>Media</th>
<th>Treatment</th>
<th>Chl $a_m$ (µg/L)</th>
<th>$P_s$ (mg/L/day)</th>
<th>$\mu_m$ (µ/day)</th>
<th>$t_d$ (/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>control</td>
<td>0.0701 ± 0.0898a</td>
<td>0.052 ± 0.0005a</td>
<td>0.321 ± 0.010a</td>
<td>2.157 ± 0.066f</td>
</tr>
<tr>
<td>NH$_4$NO$_3$</td>
<td>1</td>
<td>0.0580 ± 0.0059b</td>
<td>0.019 ± 0.0003c</td>
<td>0.157 ± 0.012c</td>
<td>4.419 ± 0.329b</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.0629 ± 0.0054b</td>
<td>0.023 ± 0.0003c</td>
<td>0.192 ± 0.008d</td>
<td>3.606 ± 0.150c</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.0685 ± 0.0024c</td>
<td>0.028 ± 0.0006b</td>
<td>0.233 ± 0.016b</td>
<td>2.978 ± 0.200f</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0.0369 ± 0.0034d</td>
<td>0.016 ± 0.0005a</td>
<td>0.096 ± 0.006e</td>
<td>7.198 ± 0.437g</td>
</tr>
<tr>
<td>Urea</td>
<td>5</td>
<td>0.0389 ± 0.0042c</td>
<td>0.021 ± 0.0002d</td>
<td>0.225 ± 0.020bc</td>
<td>3.088 ± 0.262ae</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>0.0340 ± 0.0062c</td>
<td>0.016 ± 0.0001f</td>
<td>0.209 ± 0.012f</td>
<td>3.319 ± 0.190se</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0.0278 ± 0.0041d</td>
<td>0.014 ± 0.0002d</td>
<td>0.191 ± 0.007d</td>
<td>3.634 ± 0.139e</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>0.0143 ± 0.0005d</td>
<td>0.009 ± 0.0001b</td>
<td>0.099 ± 0.007d</td>
<td>7.015 ± 0.506d</td>
</tr>
</tbody>
</table>

All values are mean ± standard deviation ($n = 3$). Different superscript letters across a row indicate significant difference between means ($p < 0.05$).

### Table 3 Protein, carbohydrate and lipid contents (% dry weight) of *S. platensis* grown on SM and the Reduced Cost media.

<table>
<thead>
<tr>
<th>Media</th>
<th>Treatment</th>
<th>Protein</th>
<th>Carbohydrate</th>
<th>Lipid</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>control</td>
<td>52.95 ± 0.530a</td>
<td>13.20 ± 0.575d</td>
<td>7.16 ± 0.683d</td>
</tr>
<tr>
<td>NH$_4$NO$_3$</td>
<td>1</td>
<td>51.30 ± 1.357ab</td>
<td>16.30 ± 0.431cd</td>
<td>6.50 ± 0.173d</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>51.70 ± 5.962ab</td>
<td>17.15 ± 1.524cd</td>
<td>6.42 ± 0.280d</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>52.62 ± 0.911a</td>
<td>15.00 ± 1.431cd</td>
<td>6.50 ± 0.113d</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>44.07 ± 0.881bc</td>
<td>24.50 ± 2.486e</td>
<td>5.64 ± 0.113d</td>
</tr>
<tr>
<td>Urea</td>
<td>5</td>
<td>47.10 ± 6.678ab</td>
<td>16.01 ± 4.236ad</td>
<td>11.01 ± 1.456c</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>45.71 ± 3.742ab</td>
<td>17.12 ± 3.096cd</td>
<td>11.31 ± 0.926c</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>43.00 ± 3.822cd</td>
<td>19.21 ± 1.761bc</td>
<td>13.01 ± 1.534b</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>37.79 ± 7.642d</td>
<td>22.05 ± 2.323ab</td>
<td>15.39 ± 1.315c</td>
</tr>
</tbody>
</table>

All values are mean ± standard deviation ($n = 3$). Different superscript letters across a row indicate significant difference between means ($p < 0.05$).
synthesis of the amino acids, which make up proteins, the increase in nitrogen concentration caused an increase in protein biosynthesis in Spirulina. With regard to lipids, higher concentrations of ammonium nitrate showed no increase in their levels. The same finding was obtained by Piorreck et al. (1984), who found that for cyanobacteria, total lipid content remained constant at all nitrogen concentrations studied. On the other hand, the biochemical composition of Spirulina grown on media supplemented with urea was changed significantly when compared with SM giving lower production of protein and higher production of both carbohydrates and lipids. Moreover, increasing the concentration of urea favored the accumulation of carbohydrate and lipids rather than proteins. The changes in biochemical composition are considered to be an adaptation mechanism to toxicity of high urea concentration causing the accumulation of carbohydrates and lipids content in the alga at the expense of protein production.

In terms of the costs of local chemical companies’ prices offered, it was found that the preparation of 1000 L of SM would cost EGP 480 (US$ 80) compared to EGP 78 (US$13) for 8.83 mM N as ammonium nitrate media (Treatment 3). This emphasizes the merits of the new modified medium, not only as a low-cost alternative but also as a highly productive input, which can be used profitably by the rural population for large-scale biomass production of protein-rich Spirulina.

Conclusion

Although, sodium nitrate seemed more optimal for S. platensis growth, ammonium nitrate and urea can serve as alternative nitrogen sources, since this cyanobacterium shows utilization of these nitrogen sources at low concentrations. The maximum dry weight, chlorophyll and protein yields were obtained using SM and the Reduced Cost medium containing 8.83 mM N as ammonium nitrate. In these media, the observed yields were statistically comparable. Any further increase in the ammonium nitrate concentration led to a considerable decrease in biomass and other parameters. This indicates the critical importance of the level of nitrogen in large scale production. The present study clearly indicates that the newly prepared Reduced Cost medium supplemented with ammonium nitrate as nitrogen source is comparable with Zarrouk’s medium regarding growth performance of Spirulina in terms of dry biomass, chlorophyll and chemical composition. Therefore, cultivation in 8.83 mM N as ammonium nitrate can be exploited when the purpose is to produce high biomass density of S. platensis with good nutritional characteristics. From a practical point of view, these results draw attention to the importance of selecting the source and concentration of nitrogen in phytoplankton cultures, because it may modify the metabolic activities and consequently, the composition and nutritional value of microalgae, which is important to consider in aquaculture practices.

References


