



# Responses of *Spirulina platensis* to a Gradient of Iron Concentrations: Growth and Physiological Indices

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## Results and discussion

The growth and photosynthetic pigments of *S. platensis* were markedly influenced by iron availability ( $P < 0.05$ ). Cultures under iron limitation (1 and 5 mg L<sup>-1</sup> Fe) exhibited a progressive increase in OD<sub>750</sub>, dry biomass and photosynthetic pigments compared to iron-starved cultures (0 mg L<sup>-1</sup> Fe), but both remained significantly lower than the control. Iron starvation (0 mg L<sup>-1</sup> Fe) resulted in the most pronounced inhibition of growth and photosynthetic pigments, underscoring the critical role of iron in cellular proliferation. No significant differences were observed between the control (10 mg L<sup>-1</sup> Fe) and the iron-enriched (15 mg L<sup>-1</sup> Fe) treatments for either OD<sub>750</sub>, dry biomass and photosynthetic pigments, indicating that *S. platensis* reached physiological iron saturation at the standard Zarrouk concentration. These results suggest that increasing iron beyond the sufficiency threshold does not confer additional growth advantages. The observed degradation of phycobiliproteins likely represents an adaptive response to minimize excess light absorption and mitigate oxidative stress when photosynthetic electron transport is impaired (Isani *et al.*, 2022; González *et al.*, 2016). Overall, these findings emphasize the importance of providing adequate, but not excessive, iron in large-scale cultivation systems, where surplus iron may precipitate and reduce bioavailability.

## References

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## Abstract

Iron is a critical micronutrient for cyanobacteria. In alkaline cultivation systems such as Zarrouk medium, iron bioavailability is often limited, making nutrient management a key factor in *Spirulina platensis* production. This study evaluated the effects of a gradient of iron concentrations (0, 1, 5, 10, and 15 mg L<sup>-1</sup> FeSO<sub>4</sub>) on growth and physiological responses of *S. platensis*. Iron limitation significantly reduced growth and pigment levels, particularly under iron starvation (0 mg L<sup>-1</sup>). No significant differences were observed between the control (10 mg L<sup>-1</sup>) and iron-enriched (15 mg L<sup>-1</sup>) treatments, indicating saturation of iron requirements. These findings highlight the importance of precise iron management and provide insights for optimizing *Spirulina* cultivation.

## Introduction

*Spirulina platensis* is a filamentous cyanobacterium extensively cultivated for nutraceutical applications due to its high protein content and abundance of bioactive pigments, including chlorophyll *a*, carotenoids, and phycobiliproteins. The biosynthesis and accumulation of these pigments are strongly influenced by nutrient availability, especially trace elements such as iron (Isani *et al.*, 2022; González *et al.*, 2016). The present study aims to evaluate the effects of a gradient of iron concentrations, from deficiency to saturation, on the growth and physiological indices of *S. platensis*. This approach allows identification of deficiency thresholds, optimal iron levels, and potential benefits of iron supplementation above standard culture conditions.

## Materials and methods

Modified Zarrouk medium (Zarrouk, 1966) was used for culturing of *S. platensis*. Samples were harvested 7 days after inoculation. Iron availability was varied to establish a gradient of five concentrations (0, 1, 5, 10, and 15 mg L<sup>-1</sup>), supplied in the form of iron sulfate. The 10 mg L<sup>-1</sup> Fe treatment served as the control, providing iron-sufficient and physiologically optimal conditions for *S. platensis*. The 0 mg L<sup>-1</sup> Fe treatment imposed iron starvation, whereas 1 and 5 mg L<sup>-1</sup> Fe were applied to induce severe and moderate iron limitation, respectively. An iron-enriched treatment of 15 mg L<sup>-1</sup> Fe was included to evaluate whether supra-optimal iron levels could further enhance growth or pigment production. Growth was monitored by measuring optical density at 750 nm (OD<sub>750</sub>) using a spectrophotometer (Ghafarizadeh & Madadkar Haghjou, 2024). Chlorophyll *a* and total carotenoids were extracted using methanol and quantified spectrophotometrically based on absorbance readings at 470, 665, and 720 nm (Zavřel *et al.*, 2015). Phycobiliproteins, including phycocyanin, allophycocyanin, and phycoerythrin, were extracted using sodium phosphate buffer and quantified by measuring absorbance at 562, 615, and 652 nm (Ajayan *et al.*, 2012).