Metabolic model of *Arthospira maxima* growth

Hugo Velasco, Roxana Olvera, Javier Loeza. Bioprocess Laboratory, Department of Biochemistry Engineering, Escuela Nacional de Ciencias Biológicas (Biological Sciences National School) Instituto Politécnico Nacional, Prolongación de Carpio y Plan de Ayala s/n. 11340. Delegación Miguel Hidalgo. México D.F. hugalvebe@yahoo.com.mx

Key words: Arthrospira, photosynthesis, CO_2, metabolic model.

Introduction. The cyanobacterium *Arthrospira* has gained considerable attention worldwide as a source of several nutraceuticals (1). It has been commercially produced for more than 30 years under solar radiation in artificial ponds (2). An attractive alternative to reduce the carbon dioxide emissions could be the use of photosynthetic microorganisms able to utilize this pollutant as a carbon source for their growth. Thus, the photoautotrophic cultivation of *Arthospira sp.* allows producing valuable biomass (3).

The objective is to design a metabolic model that can predict the growth rate and metabolites concentration at different growth conditions in a photobioreactor.

Methods. A summary of the most important reactions in the metabolism was made. The technique of extracting phycobiliproteins using modified phosphate regulator was used. The technique of extraction of chlorophyll with acetone 90% modified was used. Biomass was obtained by dry weight. Light is measured using a photodetector.

Results.

Araujo (4) used a novel design photobioreactor and found the intracellular concentration of phycocyanin and chlorophyll to increase in semi-continuous culture under constant agitation and irradiation with lamps that were not optimal for photosynthesis. Maya (5) developed a Venturi suction device for aspiring gas containing CO_2 for mixing and feeding, and found that the maximum specific growth rate for *Arthrospira maxima* (μmax) to increase when using CO_2 as a carbon source compared with $NaHCO_3$. Thus, the coupling system of the Venturi injector allows the photobioreactor to operate for optimal growth.

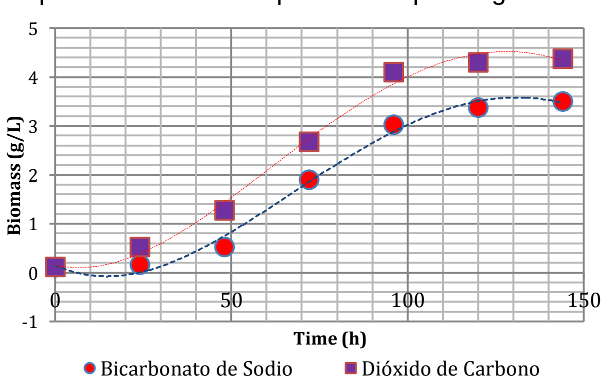

Fig.1. Biomass production rate rises significantly using carbon dioxide, compared with using sodium bicarbonate.

Figure 2 schematizes the photoautotrophic pathways network, lumping CO_2 uptake and Calvin cycle to produce Gly 3P, water photolysis to produce NADP and liberate O2, gluconeogénesis, and lower glycolisis to acetyl-CoA. This metabolite is used for biomass and chlorophyll synthesis, ATP used for maintenance is also considered.

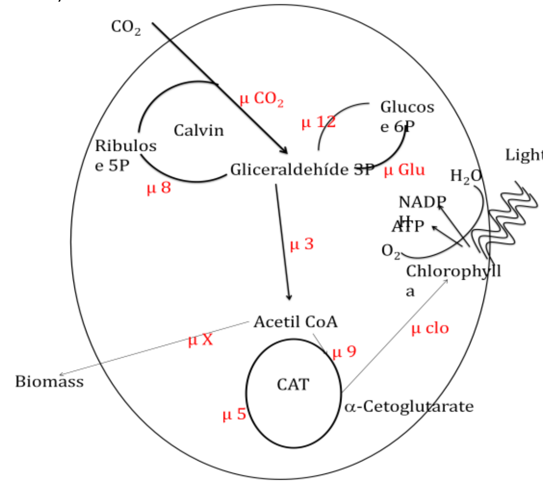

Figure 2. Outlining of the *Arthrospira maxima* metabolic model.

The stoichiometry of the lumped reactions is ueds to set up the conservation equations for Gly 3P, glucose, acetyl CoA, chlorophyll, NAD, ATP, as shown in the following equations:

$$\frac{d\varepsilon\, ATP}{dt} = -\frac{1}{3}\mu CO_2 + \mu 3 - \frac{9}{55}\mu 4 - \frac{1}{3}\mu 12 - \frac{1}{5}\mu 8 - Y\mu 6 - mATP + \varphi ATP = 0$$

$$\frac{d\varepsilon\, Ru5P}{dt} = -\frac{5}{6}\mu CO_2 + \mu 8 = 0$$

$$\frac{d\varepsilon\, Gly\ 3P}{dt} = -\frac{3}{2}\mu 3 - \mu 8 - \mu Glu + \mu CO_2 + \mu 12 = 0$$

$$\frac{d\varepsilon\, CO_2}{dt} = -\frac{1}{6}\mu CO_2 + \frac{1}{2}\mu 3 + \frac{1}{5}\mu 9 - \frac{1}{4}\mu 5 + \frac{6}{55}\mu Clor - \frac{1}{10}\mu x = 0$$

$$\frac{d\varepsilon\, Oxalacetato}{dt} = \mu 5 - \frac{4}{5}\mu 9 = 0$$

$$\frac{d\varepsilon\, Glu}{dt} = \mu glu - \frac{1}{2}\mu 12$$

$$\frac{d\varepsilon\, NAD}{dt} = -\mu 3 - \frac{1}{5}\mu 9 - \frac{1}{2}\mu 5 + \frac{8}{55}\mu Clor - \frac{1}{10}\mu x + \varphi NAD = 0$$

$$\frac{d\varepsilon\, Ac\ CoA}{dt} = \mu 3 - \frac{2}{5}\mu 9 - \mu 6 = 0$$

Conclusions. It was demonstrated that the cellular growth is better using CO_2 as carbon source than using sodium bicarbonate.

A novel experimental set up for photobioreactor operation is described.

References

(1)Belay, A., Ota, Y.,Miyakawa, K.,Shimamatsu, H., 1993. Current knowledge on potencial health benefits of *Spirulina*. J. Appl. Phycol.5, 235-241.

(2) Belay, A., 1997. Mass cultura of Spirulina outdoors-the Earthrise farms experience. In: Vonshak, A. (Ed), *Spirulina platensis(Arthrospira)*: Physiology, Cell-Biology and Biotechnology. Taylor & Francis, London, UK, pp. 131-158.

(3) L. Binaghi, A. Del Borghi, A. Lodi, A. Converti, M. Del Borghi, Batch and fed-batch uptake of carbon dioxide by *Spirulina platensis*, Proc. Biochem. 38 (2003) 1341–1346.

(4) Araujo Leyva, Cristina, 2010. Efecto de la luz y el mezclado en el crecimiento de *Spirulina (Arthrospira) máxima* en un fotobiorreactor en sistema semicontinuo. Tesis de licenciatura (Ingeniería Bioquímica) I.P.N. México.

(5) Maya, Fabian. 2011. Secuestramiento y aprovechamiento del dióxido de carbono por medio de un inyector Venturi acoplado al crecimiento de *Arthrospira máxima (Spirulina)* en fotobioreactor. Tesis de licenciatura (Ingeniería Bioquímica. I.P.N. México