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Biomass production methods: A review

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It is difficult to represent the behavior of a photosynthetic culture by simple kinetic expressions. This is specially so when the dynamic behavior of the cultures has to be considered, because of the interaction of fluid dynamics with photosynthesis. All of the mathematical models of photosynthesis available in the literature are based on the lumping of a large amount of biochemical reactions into simpler steps or into hypothetical concepts, which aim at representing the behavior of the actual biochemical apparatus. The selection of a model is, thus, the result of the compromise between the 'loyalties to biology', that is, to the elements of the biochemical steps that are quite known in the photosynthetic process, and the computational burden resulting of a complex mathematical formulation. Photosynthetic cells change the rate of biomass synthesis as the irradiance that they perceive changes. Because of this, data are collected usually after keeping the culture at a constant irradiance during considerable time. During this time, the cells adequate its photosynthetic elements to those conditions and this is detected as a change not only in production rate, but also in the cell composition, mainly as chlorophyll *a (Chla)* concentration change. This is called photo acclimation or photoadaptation. The minimal requirement for the design of a PBR is the *P–I* curve, that is, the dependence of the photosynthesis rate on irradiance, with easily measurable parameters usually called α, the initial photosynthesis rate, and Pm, the maximal photosynthesis rate, at certain irradiance Is. Thus, the parameters of the curve, in spite of being empirically determined, can be associated to the growth process and to the behavior of the culture, which depend on its physiological state. P is usually given in terms of biomass produced per unit time and unit volume (or mass) of the culture, or per unit illuminated surface. The basic P–I approach is valid only for a photo acclimated system, that is, a system that has been kept for sufficient time at each of the irradiances. If the *P–I* curve is the simplest way of representing the kinetics of photosynthesis, on the other end of the range there is a group of much more sophisticated models that can be called physiological, aiming at the representation of the dynamic behavior of photosynthetic cells, and proposing approximations to the mechanism operating inside the cells which depends on their capacity of adaptation to different illumination intensities. Those models try to express the dynamics of a photosynthetic culture taking into account a considerable amount of variables in addition of the obvious (carbon source and light), and among them various substrates that algae require for growth, as nitrate and phosphate, and also intracellular concentrations of *Chla*, the extent of light-damaged protein D1 in photosystem II (PSII), nitrogen and carbon content in the cell, etc. The goal of those advanced models is representing mathematically the actual physiology of the photosynthetic cells. An expectable drawback in this type of models is the large amount of parameters that have to be adjusted. There is still another group of models of photosynthesis that can be situated between the previous two extremes. Those are the models using the concept of photosynthetic unit (PSU), also called photosynthetic factories (PSUs).2,4,45–52 These models are especially instrumental in representing the dynamics of the photobioreactors, because they do not aim at describing the physiology of the cell but the behavior of the algal culture. The main variable considered is the light intensity, which is usually the limiting substrate in dense cultures as those focused for industrial production. It is assumed that all the other substrates are provided at sufficient rate and being in excess do not need to be taken as variables. The engineering aspects of the addition of those nutrients to the bioreactor are simply based on stoichiometry. There is a wide range of devices that have been used for the modeling of PBRs. Many of those devices are the result of ingenious invention and empirical trial & error processes. Only a small part of those have been developed via modelling and using adequate kinetic representations of the biomass growth. The poster will review critically those systems.

Biography

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